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Simulation of a California Range-Feedlot Operation

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SIMULATION OF A CALIFORNIA RANGE-FEEDLOT OPERATION

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A. N. Halter[1/] and G. W. Dean[2/]

PART I

INTRODUCTION

The problems of decision making under uncertainty have been widely recognized and discussed by economists and others. However, relatively little progress has been made in methods of systematically providing managers with improved decision-making processes for an uncertain environment. The usual approach has been one of maximizing some single objective of the firm, such as profit, under the simplifying assumption of perfect knowledge of the many variables in the system. The problem of uncertainty, if recognized at all, is handled through partial supplementary analyses, such as by "sensitivity analyses" in linear programming studies.[3/] While such partial approaches are undoubtedly useful, more attention is now being given to attacking the problem of uncertainty directly. One promising approach is statistical decision theory.[4/] Another approach is through computer simulation of various management decisions made under the full range of uncertainty encountered in reality.

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1/ Professor of Agricultural Economics, Oregon State University; Visiting Associate Professor of Agricultural Economics, University of California, Davis, California, February to July 1964.

2/ Associate Professor of Agricultural Economics and Associate Economist in the Experiment Station and in the Giannini Foundation, University of California, Davis, California.

3/ See: Heady, Earl O., and Wilfred Candler, Linear Programming Methods, Ames: Iowa State University Press, 1960, Chapters 7 and 8; and Petit, J. A., and G. W. Dean, Economics of Farm Feedlots, Berkeley: University of California, Agricultural Experiment Station Bulletin No. 800, May 1964, 44p.

4/ See: Halter, A. N., "A Review of Decision-Making Literature with a View of Possibilities for Research in Decision-Making Processes of Western Ranches," Economic Research in the Use and Development of Range Resources, Conference of the Committee on Economics of Range Use and Development, Laramie, Wyoming, July 22 and 23, 1963.

Objectives of Report

The purpose of this report is to present the results of an attempt to use computer simulation to improve the managerial decisions on a large California cattle ranch. The ranch is located in the foothill range area on the west side of the Sacramento Valley. The two most important sources of uncertainty facing the operation are (1) weather (primarily rainfall, temperature, and wind conditions) which affects the quantity, quality, and time distribution of range forage, and (2) prices of factors and products (primarily prices of feeder cattle and fat cattle, but also of feed).

The primary objective of this report is illustrative and methodological: The authors will demonstrate that computer simulation can be applied successfully and realistically in improving decisions made under uncertainty by farm operators and managers. It will be demonstrated that the philosophy and approach to management expressed in Professor Forrester's book Industrial Dynamics[1/] can be helpful in conceptualizing the management problem in agriculture. Furthermore, it will be demonstrated that a particular computer simulation language called DYNAMO is applicable to farm management problems. Because the conceptual and mechanical problems involved in setting up a DYNAMO program for an agricultural production situation are numerous and complex, a sizable appendix to the report is devoted to their detailed discussion.[2/] This appendix should prove especially useful to agricultural economists who might attempt to formulate other DYNAMO simulation models in the future.

The secondary objective of the report is to present the empirical results which were obtained through the simulation of the California range-feedlot operation. No attempt is made to investigate in full detail all aspects of the total decision process on the study ranch. Instead, the major decisions concerning the buying of feeder cattle for the range and feedlot are analyzed by simulating alternative buying decision rules over a joint distribution of price and weather conditions. Other aspects of the total decision process also are considered with suggestions as to how they might be incorporated in a more complete empirical study.

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1/ Forrester, J. W., Industrial Dynamics, Cambridge, Massachusetts, M.I.T. Press, 1961.

2/ For more detail see: Pugh, Alexander L., III, DYNAMO User's Manual, Cambridge, Massachusetts, M.I.T. Press, 1963.

The remainder of the report is divided into three sections. Part II introduces the analytical approach to the study. Part III presents a description of the ranch situation and problem. Part IV summarizes an analysis of the results obtained from the computer runs of the model. A final section points out the implications of the study to other farm management problems and to other economic problems.

PART II

INDUSTRIAL DYNAMICS

The study of industrial organizations from a systems-engineer's point of view has been denoted "industrial dynamics" by its founder J. W. Forrester.[1/] The emphasis of industrial dynamics is upon the time-varying behavior of the structure and components of an industrial organization. The principal feature of the structure of an industrial organization is its decision-making and information-feedback characteristic. The components which determine the dynamic behavior of an organization are the time delays in decisions and actions, the amplification in policies, and their interactions.

These basic ideas can be illustrated by a simple nonindustrial example with which automobile drivers are familiar.[2/] Figure 1 shows the interaction among the feedback of information obtained by the eye from viewing the street, the decision making between the eye and the hand, control between the hand and the steering wheel, and the amplification between the steering wheel and the auto.

The delay in feedback of information and the time involved in the subsequent decision making and control are so short that it is hardly noticeable to the competent driver. A time plot of the actual behavior around the desired path for most drivers would show rather small oscillations. The time path for a competent driver might appear as the oscillating solid line in Figure 2. The straight solid line is the desired path of travel.

Suppose now that the driver were blindfolded and that a companion seated next to him is included in the feedback mechanism. Then the delay between the eye and the hand would be considerably longer, for the information would have to

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1/ Forrester, loc. cit.
2/ Example based on discussion in Forrester, op. cit., pp. 14-15.

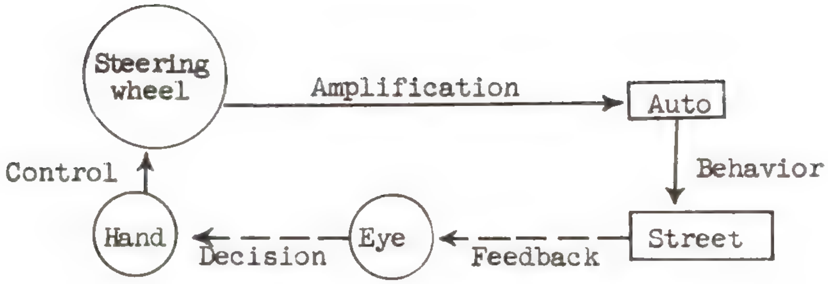

FIGURE 1. Information-Feedback Mechanism for Driving an Automobile

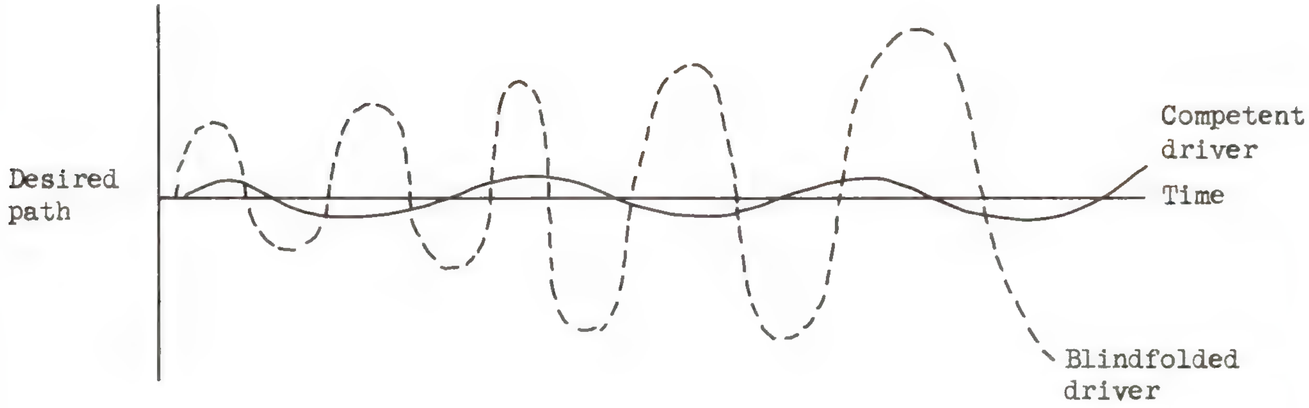

FIGURE 2. Time Plot of Various Drivers

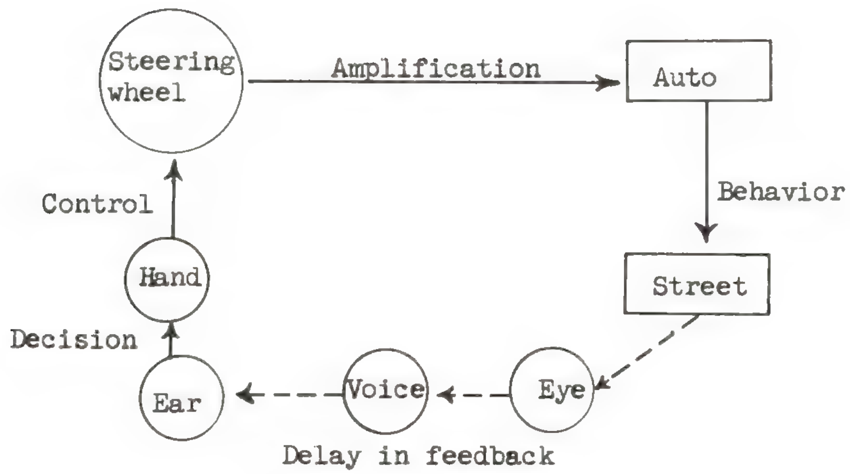

FIGURE 3. Information-Feedback Mechanism for Driving an Automobile Blindfolded

be spoken by the companion and heard by the driver before a decision could be made and control exercised. The structure appears in Figure 3.

The driver hearing his companion telling him first to turn left and then to turn right would likely overcompensate his control which could lead to larger and larger deviations between the actual and desired path. The time plot of the behavior of the auto might look like the dotted line in Figure 2.

Still more erratic would be the actual behavior if the companion could see only through the rear window. This according to Forrester is the situation in business. Management can clearly see only what has happened in the past, and provide instruction to the organization after a delay in accumulation of information and subsequent decision making. It is understandable how management overcompensates in its control, which may eventually lead to amplification of previous errors.

Industrial dynamics as an approach to improved management traces the cause and effect information feedback loops that link decisions to action in an industrial organization. A mathematical model of decision rules, information sources and other interactions among the components of an industrial system are formulated, and the model's behavior through time is generated on a digital computer. This is the simulation aspect of industrial dynamics. The validity of the model is tested by comparing computer results with all pertinent available knowledge about the actual system. Generally the model is revised by increments until it is an acceptable representation of the real system.

When an acceptable representation of the real system is achieved, then those organizational relationships and decision rules which are feasible to alter in the actual system are redesigned. The behavior of the redesigned system is tested by simulation on the computer. Comparison of new results with the former will provide the validity tests of recommended improvements in the system. There is no optimizing procedure built directly into the industrial dynamics approach or its tools, the philosophy being that social and economic systems are so complex that an optimum for the entire system is difficult or impossible to attain. Hence, improvements are made in increments.

As a means of applying the industrial dynamics approach to real problems, experts at the Massachusetts Institute of Technology developed a simulator language and computer program. This package is called DYNAMO. DYNAMO is a computer language which is relatively easy to understand and learn; i.e., at least as easy

as FORTRAN. DYNAMO runs on IBM 7090 series machines. The program is a precompiler in that it checks first for errors. It is a compiler and object program in one in that it takes only one pass on the computer to get both tabulated and plotted results.

Structure of a DYNAMO Model

The structure of a DYNAMO model is basically quite simple in that it consists of three interconnected components. These components are levels, decisions or rates, and auxiliaries. Levels are accumulations of rates; decisions control the rates of flow between levels, and auxiliaries are intervening variables that are used for writing the rate equations. The interconnections between rates and levels are shown diagramically in Figure 4. The solid lines represent flows of materials, goods, inputs or outputs, etc., while the dotted lines represent flows of information. The valve symbol represents points of decision that regulate the rates of flow between the levels. Information concerning the levels is used to make the decisions which regulate the flows. Other information concerning exogeneous factors may influence the decisions and hence the rates of flow. Examples of levels in the range-feedlot problem are the inventories of cattle on range and cattle on feed. An example of a rate is the flow of animals being placed on the range as controlled by the buying decision. Auxiliaries are variables such as range conditions and cattle prices which influence the rates of flow between the levels.

One aspect of the problem which is of upmost importance but is poorly shown by the diagram is the time dependent nature of the decision variables (rates of flow per unit of time). This dependence can be illustrated by describing the time sequence of computation in terms of levels, auxiliaries and rates. The procedure by which the computer calculates these variables is to move through time in discrete steps and calculate all the variables at each step. The diagram in Figure 5 shows the procedure graphically. The present time for which calculations are being made is called K. The length of time between calculations is denoted DT. The previous time, i.e., one DT ago, is called J and the future time is called L. The level equations are calculated first from information about levels at time J and rates over the interval JK. Next auxiliaries are calculated from information about levels and other auxiliaries at time K and rates over the interval JK. Finally rates for the forthcoming interval KL are calculated from levels and auxiliaries at time K and rates over the interval JK. After evaluation

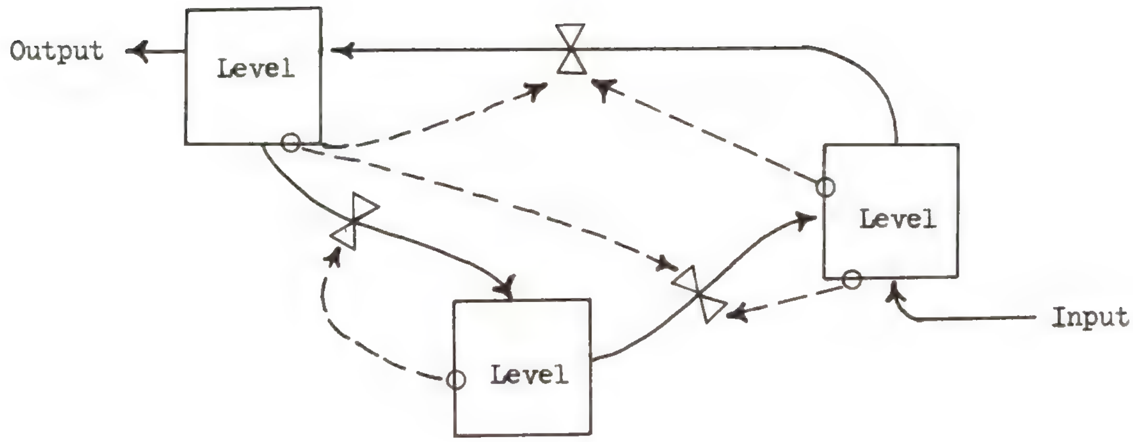

FIGURE 4. Interconnections between Levels and Rates of a DYNAMO Model

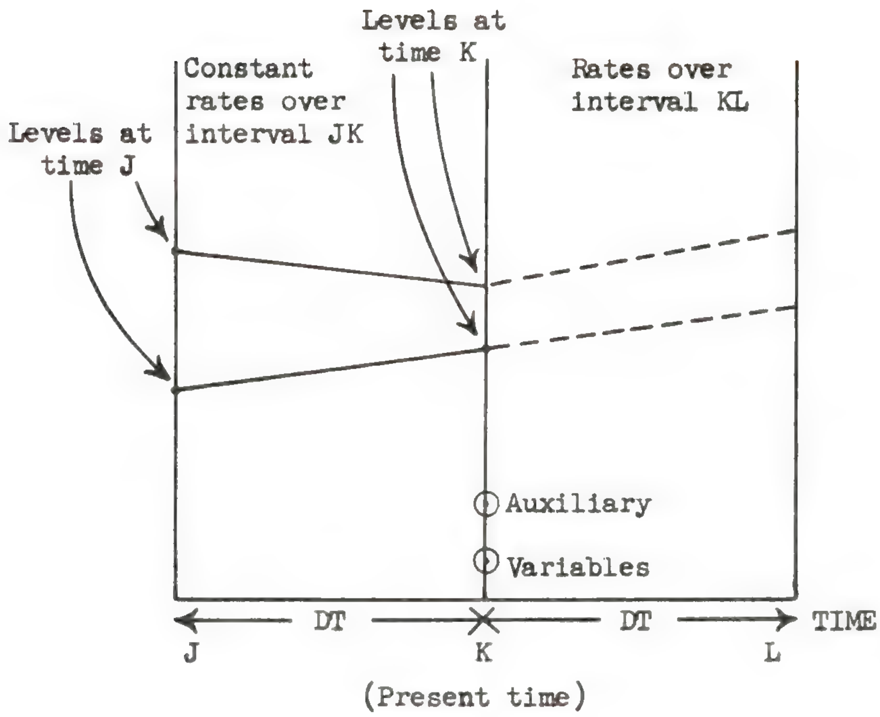

FIGURE 5. Calculation of Levels, Auxiliaries, and Rates through Time

at time K of levels, rates and auxiliaries, time is indexed forward, i.e., the J, K, L positions in Figure 5 move one time interval to the right. The K position is now J, L is K and a new L is indexed. The sequence of calculations can then be repeated to obtain new values of the variables from information about the old values. The computer in this way traces the course of the model through time as the levels lead to decisions and actions that in turn affect the levels. Thus, the interaction of the variables and their time dependency are effected.

The above discussion is to provide the reader with an idea of the approach of industrial dynamics and DYNAMO simulation. Appendix A provides a more detailed presentation of DYNAMO methodology. The research worker who wishes to formulate simulation models of new situations using DYNAMO should also find Appendix B helpful in that it presents the equations of the DYNAMO model of the range-feedlot operation described in Part III.

PART III

DESCRIPTION OF RANCH SITUATION AND PROBLEM

This section of the report provides a general description of the ranch situation and problem. First, the ranch resources and present mode of operation are described, and a summary of nonfeed costs presented. Second, the management problem to be modeled is discussed. Finally, a more detailed description of the managerial decision processes and the approach to be taken in simulating them is given.

Information about the ranch resources, costs, and decision processes of management was obtained in a series of interviews with the three managers of the ranch. The interviews were open-ended and were intended to probe into the rationale behind each of the major decisions.

Resources and Description of Ranch Operation

The ranch operation is based on two quite distinct sets of fixed resources: (1) foothill rangeland of nearly 25,000 acres and (2) a feedlot of 5,000 head capacity, a feedmill and other equipment associated with it. The entire operation is organized as a corporation, the stock of which is held in two families. Three family members form the management of the corporation, with a division of responsibilities as follows: One member manages the feedlot operation, including all

the problems of feeding, changing rations, etc. Another member is primarily responsible for the range operation as well as some general responsibilities in buying and selling. The third member has primary responsibility in buying and selling, plus some general responsibilities regarding overall management. The three men work closely together and most major decisions made by one individual receive concurrence from the other two members.

The management rents the rangeland in various sized parcels under leases with six different owners. The feedlot, mill, and associated equipment, as well as the machinery and equipment required for the rangeland operations, are owned by the management. Though the rangeland and the feedlot represent rather distinct resource situations, the two components are merged into one operating unit. The decisions with respect to both components are made by the same management with a view to profit (or other objectives) for the entire operation, not for either alone. Thus, the operations are highly interdependent, and both units are operated somewhat differently than would be typical for a range operation or feedlot operated independently.

The general scheme of operation is to start buying feeder cattle at an average weight of about 465 pounds in October for the rangeland. The management continues to buy feeders during the succeeding months through February, adjusting the stocking rate on range according to weather conditions. In a year of average or normal weather conditions, the stocking level is about 4,000 head during the winter months when the range forage supply is at its maximum. As the range feed supply diminishes due to grazing and dryer weather in the spring, the management brings the feeders off the range and into the feedlot at a rate determined primarily by range conditions. Gains obtained on range are relatively inexpensive. Hence, the strategy used is to attempt to adjust the removal rate in such a way as to utilize fully the range grass supply. Only a minimum number of light calves (about 1,200 head) are carried on the range through the summer. The average length of time that the feeders are on range is four to five months. Gains on range average about one pound per day; hence, cattle move to the feedlot at an average weight of about 600 pounds.

About 1,950 acres of the rented rangeland are suitable to barley production, with a grain crop harvested every third year. The range-barley operation requires two men full time and an extra man during the winter period.

After most of the feeders have been transferred to the feedlot, the management decides in May and June whether and how many cattle should be purchased

directly for the feedlot. Because the feedlot capacity is about 5,000 head and the rangeland capacity around 4,000 head under typical weather conditions, an average number bought is around 1,000 head. The May-June buying decision is primarily a function of the remaining capacity in the feedlot, the price of feeders, and the expected price of slaughter animals about five months later.

The feeding period extends from February to November, with an average feeding period of 145 days. No attempt has been made to adapt the lot to heavy winter feeding. In the Sacramento Valley, with heavy winter rains, this would necessitate a large investment in concrete slabs in the pens in order to eliminate muddy lots. The lot, therefore, is either emptied during the winter months or only partially filled with a few cattle (perhaps 500-1,000 head) fed through the winter on a contract basis for other cattle owners. Winter contract feeding has been excluded from the analysis in this study.

Six alternative rations have been formulated (Table 1), starting with a relatively high percentage of hay and a relatively low energy value (ration #1) and successively increasing the barley and energy value of the ration through ration #6. The feeder animals brought to the lot are fed this sequence of rations, the exact number of days on each dependent upon their weight, condition, and desired marketing time. Typically, a new lot of feeders is fed loose hay for two to three days, followed by ration #1 for seven to ten days and ration #2 for ten to twenty days. Then the animals are fed rations #3, #4, and #5 in order to put the animals on high concentrate ration #6 as soon as possible, given the weight of the animal. The management feels that 90 days is the maximum length of time an animal should be fed ration #6 because of possible digestive disturbances. Typically, the animals are fed rations #3, #4, and #5 over a period of 40 to 60 days and are fed ration #6 for about 60 to 80 days. The average feeding period is about 145 days.

The rations are batch mixed, utilizing a system of overhead storage bins for the feed components. Rolled barley is purchased frequently (daily during heavy feeding periods) and delivered to the farm in a truck owned by the feedlot. Beet pellets, protein supplement, molasses, and fat also are delivered periodically and stored in bins and tanks. Alfalfa hay and almond hulls are purchased or contracted locally and are usually bought in the period of heavy production and stored near the feedmill.

The feedlot manager determines daily the ration number and quantity to be fed to each lot of cattle, depending upon their weight, condition, and the

TABLE 1

Sequence of Rations Fed

Feed component	Unit	Ration number					
		1	2	3	4	5	6
Alfalfa hay	lbs.	350	250	150	80	40	0
Almond hulls	lbs.	350	250	200	150	100	70
Beet pulp pellets	lbs.	0	60	80	100	100	100
Rolled barley	lbs.	220	330	450	550	640	710
Protein supplement	lbs.	0	40	40	40	40	40
Molasses	lbs.	80	70	60	60	60	60
Fat	lbs.	0	0	20	20	20	20
Total ration	lbs.	1,000	1,000	1,000	1,000	1,000	1,000
Net energy per 1,000 pounds feed a/	therms	566	593	637	663	678	695

a/ Net energy estimates for individual feeds from: Morrison, Frank B., Feeds and Feeding, The Morrison Publishing Co., 21st ed., pp. 1135-1142.

quantity of the ration consumed on the previous day. Two men carry out the feeding on a twice-a-day schedule. One man breaks bales and runs the mill and batch mixer. The second man runs a self-unloading truck from the mill to the lots. Each trip takes about five minutes and the entire feeding operation is accomplished in two to three hours twice a day. In addition, a cowboy works about 60 percent of his time in the feedlot sorting out sick cattle for special treatment.

Gains in the feedlot average about 2.75 pounds per day, with a marketing weight of about 1,000 pounds after shrink. Feed conversion over the total feeding period averages about nine pounds of feed per pound of gain. The management has an arrangement with a particular packer to take most of the animals at market price at the end of feeding period. The packer is called about two weeks before the desired sale date. If the packer cannot receive cattle at that time, the management sells to other packers. Grade performance of the cattle has been about 75 percent choice and 25 percent good. Management attempts to feed to the low choice grade.

Nonfeed Costs

The nonfeed costs for an operation of this size are substantial, even though the initial cost of the feeders and the feed costs are by far the largest cost items in the range-feedlot operation. Most of the nonfeed costs are fixed irregardless of the number of animals placed on range or fed. Some nonfeed costs such as direct cash expenses in the feedlot and interest on operating capital are a function of the number of head fed.

The nonfeed cost items for the operation are summarized in Table 2. In this operation, the nonfeed costs are primarily nondeferable cash costs. That is, the rangeland is rented on a cash basis and most of the operating capital is borrowed; thus, rent and interest in this operation are cash costs. This is in contrast to many cases where the operator owns the rangeland and furnishes his own operating capital; in such cases the associated costs are primarily noncash opportunity costs. The study ranch is operated as a corporation which pays the three officers each a salary of about $10,000 per year. Profits remaining after all costs are paid are retained in the corporation or eventually paid out to the family stockholders through dividends. Because corporation dividends are double taxed, the latter alternative is seldom employed.

TABLE 2

Summary of Nonfeed Costs

Cost item	Average annual cost a/
	dollars
1. Rental for 24,740 acres of rangeland (six leases)	51,900
2. Labor cost on range (two men, full time; one man 40 percent of time)	15,000
3. Nonlabor direct cash expenses on range (gas, oil, fuel, vet, medicine, transportation, etc.)	12,700
4. Depreciation, interest, taxes, and insurance on feedlot and mill	8,100
5. Depreciation, interest, taxes, and insurance on trucks, tractors, and equipment	8,400
6. Labor cost in feedlot (two men, full time; one man 60 percent of time)	17,000
7. Nonlabor direct cash expenses in feedlot (brand inspection, gas, oil, power, repairs, vet, medicine, supplies, and telephone) = $4.80 per head	21,600
8. Interest at six percent on borrowed capital for cattle operation	35,000
9. Nonallocable overhead expenses of the entire range-feedlot (gas, oil, fuel, repair for management vehicles and general equipment, overhead foreman labor, supplies, and salaries of three corporation officers at $10,000 each)	80,000
TOTAL	249,700

a/ Items 7 and 8 based on average numbers in lot and on range. In sections reporting empirical results these are adjusted to the actual numbers in each case.

Income other than direct cattle sales is from barley produced on 650 acres of the rangeland and from manure sales from the lot. Income from these sources is shown in Table 3.

Statement of the Management Problem

The general description of the range-feedlot operation suggests the presence of a number of important managerial decision points. It would be impractical to include every decision point explicitly in a simulation model. Instead, certain key decisions have been chosen for analysis -- those which in the minds of the ranch management and the authors are among the most critical in determining the success of the firm.

First among these decisions are the rates at which feeders are purchased for the range during the fall and winter green forage period and the rates at which the feeders are subsequently transferred from the range to the feedlot for finishing.[1/] These decisions are primarily a function of range conditions as they develop through the winter and spring. Second among the critical decisions are the rates of buying of feeders directly for the feedlot in May and June. These buying decisions are a function both of actual and expected cattle prices and of the number of animals remaining on the range. All of these decisions are made in an environment about which management has imperfect knowledge. The most important variables which determine this environment are weather and prices.

Management's major problem is to devise decision policies which lead to fuller satisfaction of the objectives of the firm. The principal objectives of this particular firm relate to the level and stability of income. Specifically, management wants to raise the mean level of income without increasing the instability of income and the risk of insolvency. The simulation approach to improving managerial decisions toward this end is as follows: First, the computer model simulates the uncertain price and weather environment within which decisions are made. In total, some 400 years of range conditions and price relationships are simulated. Then, alternative decision policies are tested by simulating their performance over the 400-year distribution of price-range conditions. A policy is judged to be more successful than another if (a) it raises the mean

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1/ Because the feedlot and rangeland are operated jointly, management does not sell feeders directly off the range.

TABLE 3

Income from Sources Other than Cattle Sales

Item	Average annual return
	dollars
1. Barley sales (650 acres x one ton per acre x $43.00 per ton)	27,950[a]
2. Manure sales (5,000 cubic yards at $1.00 per yard)	5,000
TOTAL	32,950

a/ Based on average yields and prices.

income while the variance in income is held constant or lowered, or (b) it lowers the variance of income while raising or holding constant the mean level of income.

Environmental Conditions and Their Simulation

The first aspect of the simulation model described above is to generate an approximation to the actual range environment. Another aspect of the model is to provide for some historical sequence of prices. Since the generation of the range conditions is considerably more complex than the price aspect, it is singled out for detailed discussion.

Range Conditions

Because no historical record of range conditions on the study ranch exists, data on range conditions in the Sacramento Valley on the first of each month were obtained from published reports of the U.S. Crop Reporting Service for the years 1922-1964 (Appendix Table C-1). These data are based on an index of 100 representing "very good" conditions for that time of year, with 80 about "average" and 60 considered "poor." It is assumed that this index for the Sacramento Valley accurately represents the range feed supply on the study ranch.[1/] The monthly indexes of range conditions are summarized in Table 4. The number in each cell of the series of matrices shows the frequency of actual transition of range conditions from month to month over the relevant green forage period. For example, over the 42 years of observations, the range condition on December 1 took values between 66 to 75 (slightly below average) in ten years (top matrix, Table 4). In four of these years, the range condition one month later (on January 1) remained in the same 66 to 75 interval, in four other years the range condition worsened to the 56 to 65 range, in one year it improved to the 76 to 85 range, and in still another year it improved to the 86 to 95 interval. The other entries and matrices are interpreted likewise, showing the changes in range conditions from month to month. As might be expected, in most of the matrices the entries tend to be concentrated around the diagonal, reflecting the fact that range conditions tend to change only a limited amount from month to month.

The actual monthly range conditions were summarized in this way to provide a basis for devising a sampling procedure in the computer simulation model which

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1/ Thus, feed supply is taken to be a linear function of the range index.

TABLE 4

Pattern of Range Conditions, December 1 to June 1,
by Months, Sacramento Valley, 1922-1964

Range condition index, January 1	Range condition index, December 1						
	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55	1	2		1			4
56-65	2	2	4				8
66-75		2	4	3			9
76-85		0	1	5	3		9
86-95			1	3	7		11
>95					1		1
Σ	3	6	10	12	11	0	42

Range condition index, February 1	Range condition index, January 1						
	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55	2	2					4
56-65	2	4	2	1			9
66-75		2	6	3	1		12
76-85			1	5	3		9
86-95			1	0	5		6
>95					1	2	3
Σ	4	8	10	9	10	2	43

Range condition index, March 1	Range condition index, February 1						
	≤55	55-65	66-75	76-85	86-95	>95	Σ
≤55	3	2	1				6
56-65	0	1	1				2
66-75	1	5	2	4			12
76-85		1	6	3	1		11
86-95			2	2	4	1	9
>95					1	2	3
Σ	4	9	12	9	6	3	43

(Continued on next page.)

TABLE 4 continued.

Range condition index, April 1 \ Range condition index, March 1	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55							
56-65	3	1	2		1		7
66-75	2	1	4	2			9
76-85	1		5	4	1		11
86-95			1	5	4		10
>95					3	3	6
Σ	6	2	12	11	9	3	43

Range condition index, May 1 \ Range condition index, April 1	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55		2		1			3
56-65		1	0				1
66-75		3	4	2			9
76-85			3	6	1		10
86-95			1	2	7	1	11
>95		1			2	5	8
Σ	0	7	8	11	10	6	42

Range condition index, June 1 \ Range condition index, May 1	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55	2	0					2
56-65	1		2				3
66-75		1	3	0			4
76-85			4	7	3		14
86-95				3	8	5	16
>95					0	3	3
Σ	3	1	9	10	11	8	42

would closely approximate the distribution of range conditions and the correlation between range conditions in successive months. Plotting and visual inspection of the marginal distribution for December led to the adoption of a uniform probability distribution for that month, with an interval of 60.5 to 95.5. Consideration of the frequency of transition from December 1 to January 1, given the December 1 index, led to the adoption of a normal distribution for the January 1 index, with a mean equal to the December 1 index and a standard deviation of 6.25.[1/] Using the December 1 index as the mean of the January 1 distribution provides the necessary correlation between range conditions in successive months. A similar procedure was followed for each matrix shown in Table 4, with the resulting distributions shown in Table 5.

The computer simulates the uncertain weather environments by selecting the pattern of monthly range conditions in any particular year from the distributions in Table 5. For example, on December 1 a range condition is selected randomly from a uniform distribution with mean 78 and range 35. Thus, any number from 60.5 to 95.5 is equally likely to be drawn. The computer simulation provides for the correlation between range conditions by taking this number (say 85) as the mean of a normal distribution (standard deviation = 6.25) of range conditions for January 1. Suppose 82 is selected. This number becomes the mean of a similar normal distribution from which the sample range condition on February 1 (say 90) is selected. This procedure is continued through the entire season, the range condition for any month deriving from a sample distribution with mean equal to the previous month's sample value. Only two qualifications need be mentioned: First, the actual data indicate a seasonal improvement in range conditions from February through April. Therefore, a constant of 5 is added to the actual sample value in order to establish the mean of the next month's distribution in this period. Second, the form of the distribution (uniform or normal) is selected in each month to conform most closely to the historical data on range conditions.

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1/ DYNAMO is equipped to generate either normal or uniform distributions automatically, given the parameters of the distributions. Determination of these parameters by plotting and visual inspection appeared sufficiently accurate for the purposes at hand. Insufficient observations were available for each of the conditional distributions to allow meaningful direct derivations of the probability distributions statistically.

TABLE 5

Selected Parameters of Distributions of Monthly Range Conditions

Time	Form of distribution	Parameters of distribution			
		Mean	Range	Interval	Standard deviation
		range index			
December 1	uniform	78	35	60.5-95.5	--
January 1	normal	sample no. Dec. 1	--	--	6.25
February 1	normal	sample no. Jan. 1	--	--	6.25
March 1	uniform	sample no. Feb. 1 + 5	20	--	--
April 1	uniform	sample no. Mar. 1 + 5	20	--	--
May 1	normal	sample no. Apr. 1	--	--	6.25
June 1	normal	sample no. May 1	--	--	6.25

Prices

Prices of feeders, slaughter animals, and feed costs were obtained from published reports of the U.S. Department of Agriculture (Appendix Table C-2). Feeder and slaughter animal prices were those which actually existed at the Stockton market for the period 1954-1963. This is approximately the period over which the study ranch had been in operation. Feed costs were based on local mill market prices. The historical sequence of prices is used directly in the simulation model in contrast to the procedure of generating range conditions.

Decision Processes of the Range-Feedlot Management and the Approach to Their Simulation

To provide a clear conception of the management's decision processes and to make the discussion of their simulation more meaningful, this section explains in considerable detail the flow of cattle through the range and feedlot, showing where the critical decision points lie. It shows the time sequence of events throughout the year and the way in which management, through the decision process (decision rules), continuously adjusts the operation as new information on range conditions and prices become available.

A diagram of the range-feedlot problem is shown in Figure 6. Although schematic representation of the main levels, rates, and auxiliaries may not be necessary in the development of the model equations, it is a great aid in understanding the problem.[1/] Levels are shown as rectangular boxes, decisions concerning rates as valves, and auxiliaries as circles. Solid lines represent movement of animals; dotted lines show the dependence of decisions upon information concerning levels and auxiliaries. The feedback nature of the problem is obvious from the diagram; e.g., information concerning the level of cattle on range is fed back to influence the buying decision.

A monthly calendar of the numbers of cattle which move on to the range, off the range, and into and out of the feedlot is shown in Figure 7. Because the ranch has both a range operation and a feedlot, the management has devised buying and stocking decision rules which are more continuous than for the typical range operation. A more typical range operation involves buying feeders once or twice

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1/ Forrester (*op. cit.*, p. 81) advocates a diagram prepared in considerably greater detail than presented here.

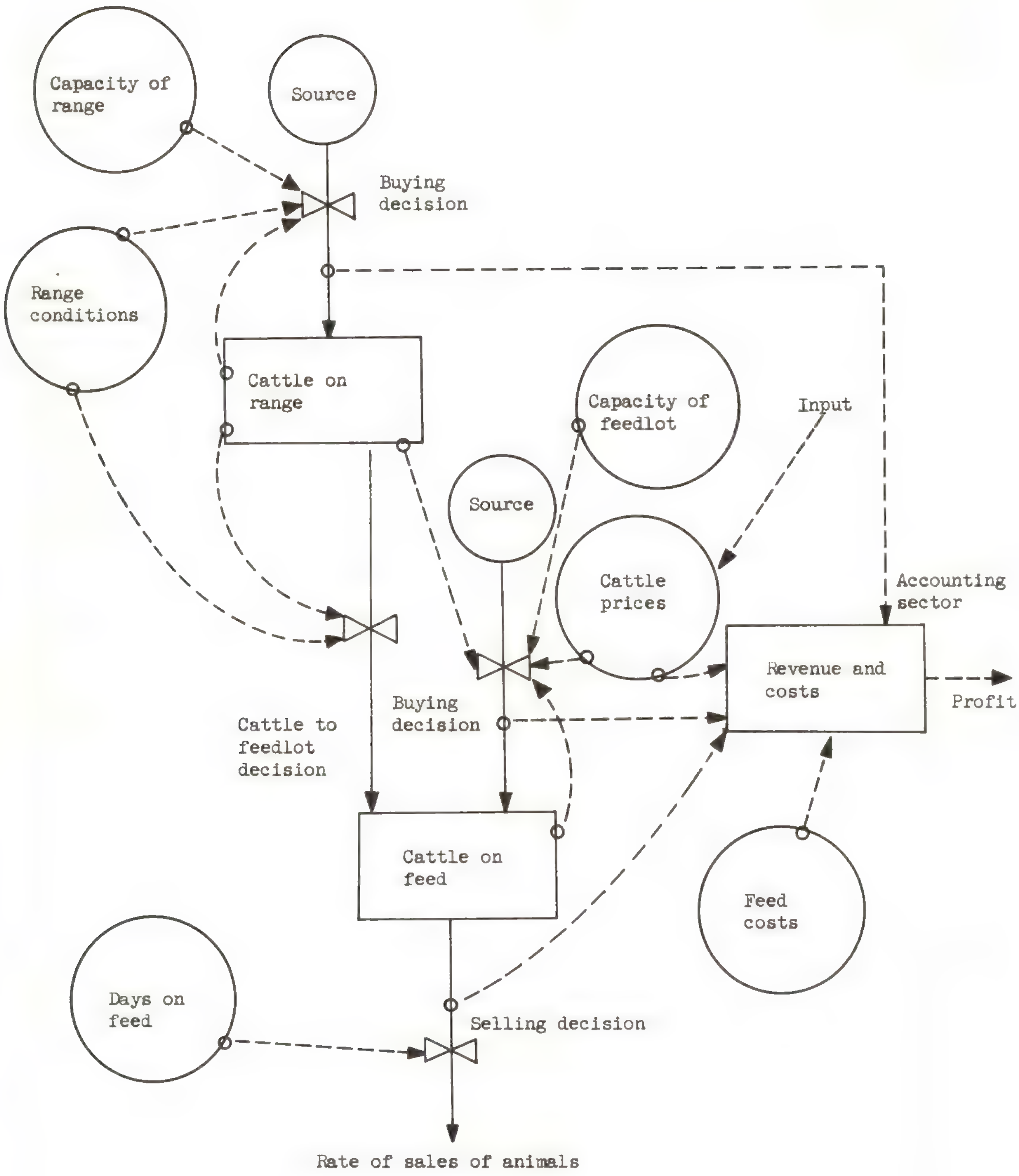
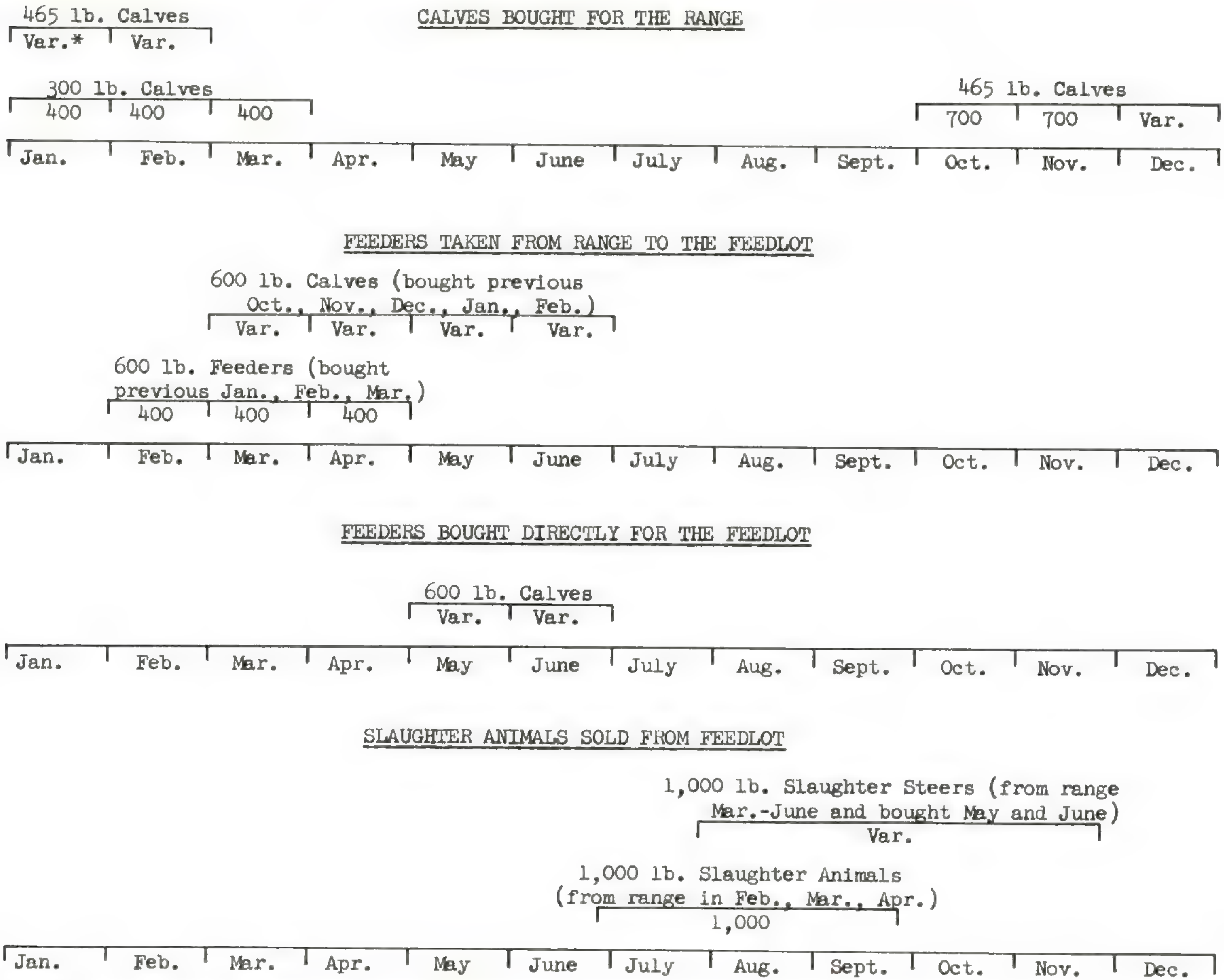


FIGURE 6. Diagram of Range-Feedlot Operation



*Var. = a variable number per month depending on range conditions, beef prices, or both.

FIGURE 7. Calendar of Cattle Rotation on Range and in Feedlot (number per month)

in the fall and winter, based on the management's policy regarding stocking rates under uncertain range conditions and cattle prices.1/ In fact, the study ranch was operated much in this fashion prior to about 1954. More recently, the management has consciously attempted to develop a rotation of cattle through the range to spread out the timing of purchases and sales to avoid the high income variability associated with buying and selling cattle once a year. As such, the decision rules used by the management and incorporated in the initial simulation model probably represent a substantial degree of improvement over typical range operations.

Decisions on Buying Feeders for Range

The first calves are purchased for the new winter range year starting in October. The winter green forage period starts only after a period of rains in the late fall and early winter. Depending on the particular year, substantial green feed may be initially available as early as November or as late as February. However, the management of the ranch has determined that, even in an extremely unfavorable range year, the approximately 25,000 acres of range will carry a minimum of about 3,000 head of feeders during the winter months. The management buys this minimum number regardless of the range and price conditions. They then buy additional numbers of feeders as actual range conditions develop and can be observed.

The 700 head per month of 465-pound calves purchased in October and November (Figure 7) are part of the basic 3,000 head purchased regardless of range conditions. The remainder of the 3,000 are lighter calves (300 pounds) purchased in January, February, and March (400 per month). These lighter animals stay on the range about 13 months before moving to the feedlot as feeders weighing about 600 pounds. Thus, if minimum range conditions were to occur throughout the winter and spring, the management would purchase 2,600 head (1,400 in October and November and 1,200 in January, February, and March). Because the 1,200 calves are left on the range for 13 months, the range is stocked with 3,000 head in January, February, and March.

1/ For an analysis of range stocking problems under these more typical conditions using statistical decision theory see: Dean, G. W., A. J. Finch, and J. A. Petit, Jr., Economic Alternatives and Strategies for a California Foothill Range Beef Cattle Operation, Berkeley: University of California, Agricultural Experiment Station Bulletin (forthcoming).

These buying decisions are based on the following rationale: The feeders are purchased in October and November before new grass becomes available because feeders are in plentiful supply and feeder prices are at an annual low in this season (Appendix Table C-2). The 300-pound calves are purchased to obtain some lighter animals with a relatively low price risk. They are purchased in January, February, and March because the management can then obtain calves which, because they were weaned earlier in the fall, are in condition to gain efficiently on pasture.

A variable number of 465-pound calves are purchased at frequent intervals during December, January, and February as information becomes available on the actual range conditions for that year. Management observes these conditions as frequently as they think changes may occur. Naturally, they do not survey the entire 25,000 acres; but on the basis of sample checks a judgment concerning the condition of the range is made. On the basis of this information the management makes a decision concerning stocking rates.

In interviews with the management, maximum and minimum stocking rates were determined. For example, if "very good" range conditions continued for all three buying months, the maximum number (800) would be purchased each month for a total of 5,000 head (1,400 feeders in October and November, 1,200 calves in January, February, and March, and 2,400 feeders in December, January, and February). If "very poor" range conditions continued for all three buying months, the minimum number (133) would be purchased each month, for a total of 3,000 head (1,400 feeders in October and November, 1,200 calves in January, February, and March, and 400 feeders in December, January, and February). Thus, the buying decisions for range consist of a minimum constant number each year, plus additional feeders purchased at a rate determined by range conditions as they develop through the period. A more comprehensive analysis might also consider the stocking rate as a function of cattle prices. However, the cheap gains on the range make prices relatively less important than in the decisions where cattle are purchased directly for the feedlot and gains are very expensive.

In simulating management's actual decisions on buying feeders for range, stocking levels were related to range conditions through a series of mathematical functions. An example where the stocking level is an increasing function of range conditions is shown in Figure 8. The range conditions are those simulated by the model.

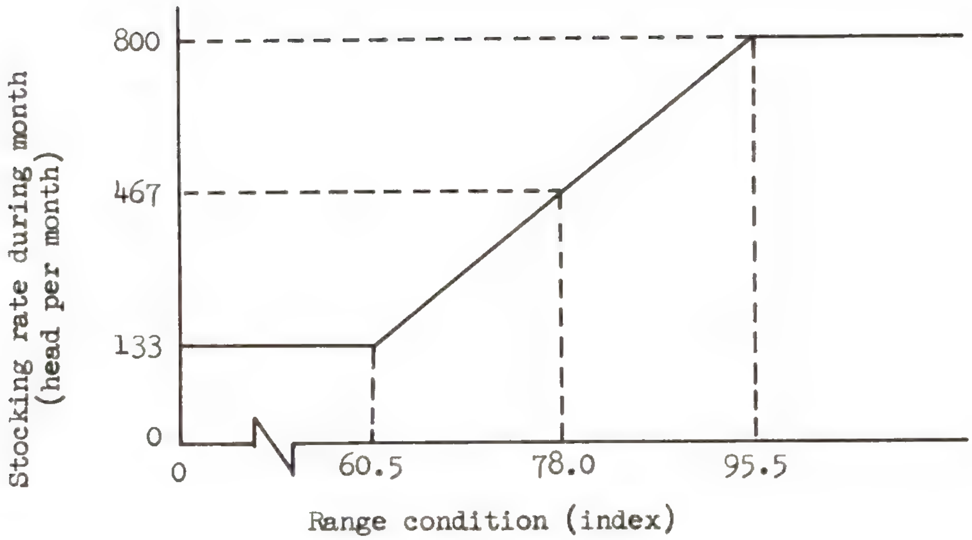


FIGURE 8. Stocking Rates in December, January, and February as a Function of Range Conditions

For example, if range conditions are "very good" (index of 95.5 or higher), the model simulates buying cattle at the maximum rate in December (800 head per month). If the range conditions are "very poor" (an index of 60.5 or lower), the model simulates stocking at the minimum rate (133 head per month). For intermediate range conditions, the model simulates stocking at an intermediate rate as determined by a linear function between the minimum and maximum.

Decisions on Transferring Feeders from Range to Feedlot

The decisions as to the rates of transfer of feeders from the range to the feedlot are divided into two categories: (1) a decision to remove the 1,200 head of calves purchased 13 months earlier over the period February, March, and April (400 per month, Figure 7); and (2) a set of decisions concerning variable rates at which to transfer the feeders (purchased October to February) over the four-month period, March 1 to July 1.

In the second category of decisions above, cattle are first transferred to the feedlot in March. At the first of March, the management knows the total number of cattle on the range since all purchases are completed by that time. If range conditions continue throughout the remaining period at a level comparable with those during the buying period, the cattle would be removed at a nearly uniform rate month by month from March 1 through July 1. However, management realizes the range conditions are likely to be highly variable, and hence they attempt to be flexible in their transfer rates. Suppose, for example, that a normal number of cattle were on range at the start of the transfer period. If range conditions deteriorate sharply, a drastic reduction in cattle numbers would be needed to completely adjust to this condition. However, management follows a policy of removing fewer animals than necessary for a complete adjustment, because it desires to be in a position to utilize an increase in feed supply which may result from a later improvement in range conditions. On the other hand, if range conditions improve markedly, management would need to maintain cattle numbers to utilize the feed supply, and hence no animals would be transferred to the lot. However, management follows a policy of removing some animals in case range conditions deteriorate later.

In the simulation, management's transfer decisions were formalized through the relationships shown in Table 6. The left-hand side of Table 6 shows the usual transfer rates month by month for the maximum, average, and minimum numbers

TABLE 6

Usual Transfer Rates as a Function of Cattle Numbers, and Desired Numbers as a Function of Range Conditions, Respectively

Month	Number of cattle on range, first of month	Usual transfer rate during month	Range condition first of month	Desired number of cattle on range first of month
March	3,800 2,800 1,800	950 700 450	-- -- --	-- -- --
April	2,850 2,100 1,350	950 700 450	95.5 78.0 60.5	2,850 2,100 1,350
May	1,900 1,400 900	1,050 800 550	95.5 78.0 60.5	1,900 1,400 900
June	850 600 650	850 600 350	95.5 78.0 60.5	850 600 350

of cattle on range.[1] Intermediate rates are a linear function of intermediate cattle numbers between the minimum and maximum. The right-hand side of Table 6 shows for the first of each month the desired number of cattle on range for selected range conditions. The desired number is a linear function of range conditions between the maximum and minimum. If the range condition is above 95.5, the desired number remains constant at the maximum; if the range condition is below 60.5, the desired number remains constant at the minimum.

In the simulation model, the response delay in the actual transfer rate off range is formalized in the following equation:

$$\begin{bmatrix}\text{Actual transfer rate off}\\ \text{range during month}\end{bmatrix} = \begin{bmatrix}\text{Usual transfer rate off}\\ \text{range during month}\end{bmatrix} +$$

$$k \begin{bmatrix}\text{No. on range} & - & \text{Usual transfer rate off} & - & \text{Desired no. on range}\\ \text{first of month} & & \text{range during month} & & \text{first of next month}\end{bmatrix}$$

where k is the factor which represents the response delay.

To illustrate the above equation, consider an example in which range conditions have been excellent up to March 1 but are deteriorating during March. The range would be stocked with 3,800 animals on March 1. The usual transfer rate from Table 6 would be 950 head if these excellent conditions continued. Suppose the range condition on April 1 happens to be only average (78.0). Then the desired number to have on range April 1 from Table 6 would be 2,100. This implies that 1,700 head (3,800-2,100) should be removed in March to reach this desired number. Assuming a response delay factor of 0.5 for illustrative purposes, and substituting the numbers in the above equations we obtain:

$$\begin{matrix}\text{Actual rate off}\\ \text{range during March}\end{matrix} = 950 + 0.5\ (3,800 - 950 - 2,100) = 1,325.$$

The same equation applies when range conditions improve. For example, suppose that there were 2,800 head on range March 1 implying a usual removal rate of 700 head. Suppose that range conditions on April 1 improved to 95.5 implying a desired number of 2,850 on April 1. To reach this desired number, the model would simulate a situation in which all transfers are stopped and 50 additional animals

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1/ The 1,200 head transferred at a constant rate are not included in Table 6.

are purchased. However, the simulated response delay of 0.5 would provide a transfer rate half way between the usual rate of 700 and the desired rate of -50. Substituting the numbers of this example in the equation above, we obtain an actual removal rate of 325 head:

$$\text{Actual rate off range during March} = 700 + 0.5\ (2{,}800 - 700 - 2{,}850) = 325.$$

This same type of equation is used to determine actual transfer rates during March, April, and May. The simulated model selects a June removal rate which transfers the remaining cattle on the range to the feedlot.

The Response-Delay Factor

The response-delay factor can be interpreted in terms of a stock-flow concept of the range feed supply. A stock concept of the feed supply is that the total amount of feed to be available in the spring months is determined by March 1. Therefore, subsequent changes in weather would not affect the total feed supply. In this case, $k = 0$ and cattle would be transferred to the lot at the usual rate. A flow concept of the feed supply is that the amount of feed to be available each month is determined only by the range condition during that month. In this case, $k = 1$ and cattle numbers would be completely adjusted to range conditions. As mentioned above, management's policy is based on neither one of these extremes but rather on an intermediate policy. Discussion with management on how they would act under different circumstances suggested a response-delay factor of $k = 0.5$ as a reasonable first approximation in the simulation model.

Decisions on Direct Buying for the Feedlot, May and June

The capacities of the rangeland and the feedlot are nearly matched. If maximum range conditions exist, about 5,000 feeders are purchased to utilize the range. The feedlot capacity also is about 5,000 head. Thus, in an exceptionally good range year, the cattle from the rangeland fill the feedlot virtually to capacity. However, in a more typical or poor range year, the feedlot has excess capacity and feeders may be purchased directly for it. The management's decision on the number to buy depends on the amount of excess capacity in the lot and upon cattle and feed prices. These direct purchases take place in May and June.

Specifically, the first step that management takes is to calculate the maximum number which can be bought, i.e., the number which will fill the lot to capacity. The calculation is:

$$\begin{bmatrix}\text{Maximum no.}\\ \text{to buy, May}\\ \text{and June}\end{bmatrix} = \begin{bmatrix}\text{Feedlot}\\ \text{capacity}\end{bmatrix} - \begin{bmatrix}\text{No. in the}\\ \text{lot, May 1}\end{bmatrix} - \begin{bmatrix}\text{No. on the range}\\ \text{May 1, to transfer}\\ \text{to lot in May \& June}\end{bmatrix} + \begin{bmatrix}\text{Expected no.}\\ \text{sold from lot,}\\ \text{May and June}\end{bmatrix}$$

Suppose there are 3,000 head in the lot in May and 1,000 still on the range (aside from the usual 1,200 calves which stay on the range). Feedlot capacity is 5,000 and 200 slaughter steers are expected to be sold from the lot in May and June. The maximum number to buy in May and June is then calculated to be 1,200.

$$\begin{bmatrix}\text{Maximum no. to buy,}\\ \text{May and June}\end{bmatrix} = 5{,}000 - 3{,}000 - 1{,}000 + 200 = 1{,}200.$$

The actual number purchased will vary from zero to this maximum number, depending on how management evaluates the prospects of profit on the direct purchases. Since all other costs are essentially fixed in the short run, the purchase will be profitable if the gross income of the finished animal exceeds the initial feeder cost plus feed costs.[1/] The procedure used by management is to formulate an expectation of slaughter prices 145 days later for September, October, and November. Then taking the initial weight, final weight, and feed costs, management computes the break-even feeder price. The calculation is as follows:

$$\text{Break-even feeder price} = [(\text{Expected slaughter price})(\text{Final weight}) - (\text{Days on feed})(\text{Feed cost per head per day})] \,/\, \text{Initial weight}.$$

For example, if the expected slaughter price is $25.00 per cwt, initial weight is 600 pounds, final weight is 1,000 pounds, and the animal is fed 145 days at a feed cost of $0.58 per head per day, the break-even feeder price is $27.65 per cwt.

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1/ See Appendix Tables C-2 and C-3 for feeder prices, slaughter prices, and feed prices over the 1954-1963 period considered.

$$\text{Break-even feeder price per pound} = \frac{(0.25)\ (1.000) - 145\ (0.58)}{600} = 0.2765.$$

This break-even feeder price is compared with the actual feeder price in order to determine the number to purchase. If the actual feeder price is higher than break-even feeder price, no cattle are purchased since not even variable costs could be expected to be covered. If the actual feeder price is lower than the break-even feeder price, a variable number are purchased, depending on the difference between the actual and "break-even" price. If the slaughter price, feed prices, gains, and feed conversion data all were known with certainty, then the most profitable course of action would be to buy the maximum number as soon as the actual feeder price dropped below the break-even price. However, management does not know the slaughter price with certainty at the time of the decision; hence, it formulates an expectation of the slaughter price 145 days later. Management has used the September-October-November price in the previous year as a forecast of this year's price during the same period. Because of the possible inaccuracy of the forecast, management makes an allowance for uncertainty in their determination of the number to buy. Recently, the uncertainty margin used by management has been about $3.00 per cwt. Suppose that the feedlot can hold another 1,000 head (maximum number to buy) and that the calculated break-even feeder price if $25.00 per cwt. Management would then purchase 1,000 head when the actual feeder price is less than $22.00 per cwt. When the actual feeder price is greater than $25.00 per cwt, management would make no purchases. If the price falls between $22.00 and $25.00 per cwt, then management adjusts its purchases to some intermediate number.

In the simulation of the decisions on direct buying the equation for the maximum number to buy was programmed directly. The model calculates the number to buy in May and June by multiplying the maximum number to buy by the buying rate adjustment constant. This constant is taken from a graph similar to the one shown in Figure 9. If the actual feeder price is greater than P_1, the buying rate adjustment constant equals zero and no feeders are purchased, whereas if the feeder price is less than P_0, the constant equals one and the maximum number of feeders is purchased. Between P_0 and P_1 the model selects the buying rate adjustment constant between zero and one according to the function specified.

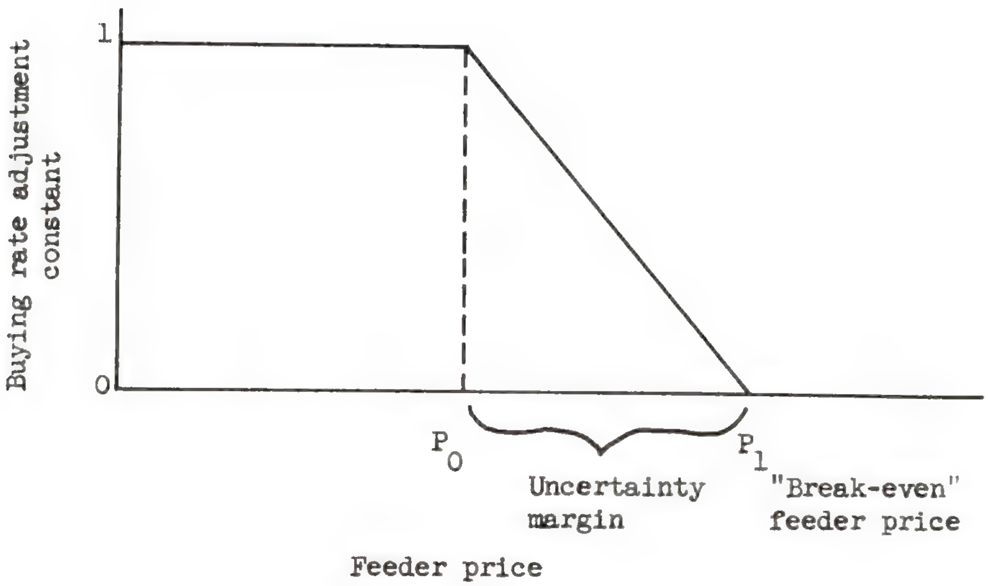

FIGURE 9. Determination of Buying Rate Adjustment Constant for Direct Feeder Purchases in May and June

Proposed Improvements in Price Expectation Models

From previous experience with the economics of cattle feeding, the authors hypothesized that some improvement in management policy could be effected by selection of a less naive price expectation model. Thus, in the computer simulation, three alternative slaughter price expectation models were used, each coupled with an uncertainty margin of a different length. The models are summarized in Table 7. Model A is an approximation to the one actually used by management wherein prices are forecasted based on last year's price and an uncertainty margin of $3.00 per cwt is used. Model B assumes perfect knowledge of slaughter prices and is used as a norm in making comparisons with more realistic models. A small uncertainty margin of $0.25 per cwt is included to recognize other sources of uncertainty (in gains, feed conversion, and feed prices). Model C was developed by the authors as a simple alternative price expectation model which management might adopt. This model uses the current May-June slaughter price adjusted for average seasonal change as the September-November slaughter price expectation. Over the period 1954-1963 the forecasting errors from this model were only about one-third of those from Model A.[1/] Correspondingly, the uncertainty margin was reduced to one-third of that for Model A.

Decision in Feeding and Sales

The decisions regarding the feedlot sector are important to the success of the business. The feedlot sector is likened to a factory which processes raw materials and sells them at the market price after a fixed production period delay. As discussed previously, however, the feeding decisions such as day-to-day adjustments in quantities and type of ration and sales policy are not subjected to detailed simulation. Although the ranch data show some variation among lots in rates of gain, feed conversion, timing of ration sequences, days on feed, and grade of slaughter animals, it was felt that conditions could be held constant at their mean values with relatively little loss in the value of the results. These constants are summarized below:

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1/ The sum of the squared deviations between actual and forecasted prices for Model C was one-third of that for Model A.

TABLE 7

Price Expectation Models for May-June Buying of Feeders
Directly for the Feedlot

Model designation	Price expectation for slaughter cattle Sept.-Oct.-Nov., year t, equal to:	Uncertainty margin
		dollars per cwt
A	Actual price, slaughter cattle, Sept.-Oct.-Nov., year t-1	3.00
B	Actual price, slaughter cattle, Sept.-Oct.-Nov., year t	0.25
C	Current slaughter price in May-June, year t, adjusted for average seasonal change from May-June to Sept.-Oct.-Nov.	1.00

1. Initial weight of feeders into the feedlot: 600 pounds[1/]
2. Initial grade of steers purchased directly for the feedlot: 50 percent choice, 50 percent good
3. Gains: 2.75 pounds per day
4. Feed conversion: 9.00 pounds of feed per pound of gain
5. Ration sequence: Ration #1 through #6 as specified previously
6. Days on feed: 145 days
7. Final slaughter weight (after shrink): 1,000 pounds
8. Final slaughter grade: 75 percent choice, 25 percent good.

With these variables held constant at their means, the simulation model can thus concentrate on the influences of weather and prices on the performance of the range-feedlot system under alternative decision rules.

PART IV

EMPIRICAL RESULTS

The model described in the previous section was run on the IBM 7090 computer at the University of California in Berkeley.[2/] The model simulates the uncertain environment in which the decisions are made as well as the day-by-day decisions made in response to the changing environment. A single run of the model simulates 40 years of range conditions for a given set of prices. In total, 10 years of price relationships, those for 1954 through 1963, were run. Thus, some 400 years of range conditions and price relationships were considered. Each run of the model generated the same set of range conditions through the 40 years so that the effect of different prices in successive runs could be compared.

The data and results which were available for summarization became quite voluminous. Therefore, the results which follow are summarized in a number of subsections. The first summarizes and compares the simulated range conditions with the actual conditions indicating the goodness of fit of the simulated environment to the actual. The second subsection summarizes the simulated buying and transfer

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1/ This weight is an overall average. Actually, the weight of feeders off the range varies somewhat depending on the number of days they are kept on range.

2/ A complete discussion of the equations of the model are given in Appendix B.

decisions for cattle moving on and off range as well as the buying decisions in May and June for the cattle bought directly for the feedlot. The third subsection summarizes the simulated net income levels and frequency distributions over the 400 years of range-price conditions. This initial simulation attempts to portray the type of outcomes which management could expect in the long run, given the uncertain environment and management's present decision policies. The frequency distributions of net income provide a clear picture for management to consider in evaluating its present decision procedures or in formulating revised decision procedures. The final subsection presents the results from the authors' attempt to improve one aspect of the management's decision procedures, namely the price expectation model used in the May-June buying decisions.

Simulated Versus Actual Range Conditions

A question of primary importance in this study concerns the realism of the simulated range conditions as developed through a series of monthly samples. A measure of the goodness of fit of the simulated conditions to actual range conditions is the comparison given in Table 8. The first figure in each cell represents the actual range condition data, the second figure the sample data. All other cells contain zeros. Although no statistical tests have been computed due to the small numbers of observations in some cells, visual observation of the cell entries and border totals reveals a reasonably close correspondence between actual and simulated range conditions. The only systematic divergences appear to be that the simulation slightly underestimated the number of observations in the lowest category (≤ 55) in the first months and overestimated the number of observations in the highest category (>95) in the last four months. The underestimation of the number of low range conditions was apparently due to setting a sampling range slightly too small for the first months. The overestimation of the number of high range condition resulted from the fact that no absolute upper limit such as 100 was specified. For example, if 99 was selected in May, the June index was selected from a normal distribution about a mean of 99, thereby permitting values well over 100. The practical importance of this problem is slight because the rate of cattle placed on range remains constant for range indexes above 95. However, an absolute upper limit of 100 on the sample values would have provided slightly more realistic estimates of the range conditions *per se*.

TABLE 8

Comparison of Actual and Simulated Range Conditions, December 1 to June 1, by Months, Sacramento Valley, 1922-1964 a/

Range condition index, January 1	Range condition index, December 1: ≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55	1-0	2-0		1-0			4-0
56-65	2-0	2-6	4-0				8-6
66-75		2-0	4-7	3-3			9-10
76-85		0-1	1-2	5-7	3-2		9-12
86-95			1-0	3-2	7-8		11-10
>95					1-2		1-2
Σ	3-0	6-7	10-9	12-12	11-12	0-0	42-40

Range condition index, February 1	Range condition index, January 1: ≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55	2-0	2-2					4-2
56-65	2-0	4-4	2-2	1-1			9-7
66-75		2-0	6-7	3-4	1-0		12-11
76-85			1-1	5-5	3-1		9-7
86-95			1-0	0-2	5-7		6-9
>95					1-2	2-2	3-4
Σ	4-0	8-6	10-10	9-12	10-10	2-2	43-40

Range condition index, March 1	Range condition index, February 1: ≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55	3-0	2-0	1-0				6-0
56-65	0-2	1-0	1-0				2-2
66-75	1-0	5-7	2-7	4-1			12-15
76-85		1-0	6-2	3-3	1-0		11-5
86-95			2-2	2-3	4-2	1-0	9-7
>95					1-7	2-4	3-11
Σ	4-2	9-7	12-11	9-7	6-9	3-4	43-40

(Continued on next page.)

TABLE 8 continued.

Range condition index, April 1 \ Range condition index, March 1	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55							0-0
56-65	3-0	1-2	2-0		1-0		7-2
66-75	2-0	1-0	4-7	2-1			9-8
76-85	1-0		5-7	4-2	1-1		11-10
86-95			1-1	5-2	4-4		10-7
>95					3-2	3-11	6-13
Σ	6-0	2-2	12-15	11-5	9-7	3-11	43-40

Range condition index, May 1 \ Range condition index, April 1	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55		2-2		1-0			3-2
56-65		1-0	0-1				1-1
66-75		3-0	4-6	2-3			9-9
76-85			3-1	6-7	1-2		10-10
86-95			1-0	2-0	7-5	1-0	11-5
>95		1-0			2-0	5-13	8-13
Σ	0-0	7-2	8-8	11-10	10-7	6-13	42-40

Range condition index, June 1 \ Range condition index, May 1	≤55	56-65	66-75	76-85	86-95	>95	Σ
≤55	2-2	0-1					2-3
56-65	1-0		2-2				3-2
66-75		1-0	3-7	0-2			4-9
76-85			4-0	7-8	3-0		14-8
86-95				3-0	8-4	5-2	16-6
>95					0-1	3-11	3-12
Σ	3-2	1-1	9-9	10-10	11-5	8-13	42-40

a/ First figure in each cell represents the actual data; the second figure the simulation sample data. All other cells are zeros.

Table 9 shows the simulated range conditions month by month over the 40 years. In the first year of the simulation, DYNAMO automatically sets all sample values at their mean. An indication that the simulation realistically portrayed actual range conditions is that the means of the 40 years of sample range conditions do in fact equal those in the initial "normal" year.

Simulated Buying and Transfer Decisions

One matter of interest to management is to obtain estimates of the variability in numbers of feeders placed on the range each year. A total of 2,600 head are placed on range regardless of range conditions; however, additional feeders are purchased as a function of range conditions. The left-hand side of Table 10 shows this variable number purchased in December, January, and February depending on range conditions. The final column in Table 10 shows the total number placed on range. The minimum number placed on range is for simulated range year 29. Here the indexes of range conditions in December, January, and February are 62, 56, and 50, respectively (Table 9), and only 154, 128, and 128 head are purchased in these months (Table 10). Thus, only 3,010 head (2,600 + 154 + 128 + 128) in total are placed on range in year 29. In year 26, on the other hand, range conditions were excellent with indexes of 91, 96, and 101 in December, January, and February, respectively. In these months, 718, 795, and 795 head were purchased and, together with the constant number of 2,600, make a total of 4,908 placed on range. Thus, the number placed on range varied by about 1,900 head (4,908-3,010) over the 40-year period of simulated range conditions.

The frequency distribution of cattle placed on range and subsequently transferred to the feedlot over the 40 years of simulated range conditions is given in Figure 10. Although the probability of nearly "normal" cattle numbers is highest (3,800-4,000 head), the distribution shows a tendency for rather high probabilities at the extremes of the interval from 3,000 to 5,000. This information is important to management in that financial and production planning must be geared to rather high probabilities of extreme fluctuations in cattle numbers from year to year.

The rates at which the cattle purchased for the range are transferred to the feedlot are shown monthly in the right-hand side of Table 10. The 1,200 head of calves placed on range a year previously are transferred to the feedlot at a

TABLE 9

Simulated Range Conditions (Index)

Year	Simulated range index							Mean	Revised mean
	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Dec.-June	Dec.-June a/
1	78	78	78	83	88	88	88	83	83
2	90	92	95	99	107	110	112	101	97
3	89	87	86	86	98	96	95	91	91
4	77	75	73	70	68	67	65	71	71
5	62	56	51	62	61	55	50	57	57
6	72	70	67	80	87	84	81	77	77
7	90	86	81	89	104	99	94	92	91
8	84	79	73	87	86	81	75	81	81
9	80	79	77	81	78	77	75	78	78
10	90	77	63	67	74	61	47	68	68
11	80	95	109	124	135	150	164	122	97
12	72	68	64	73	84	80	76	74	74
13	75	76	78	75	87	88	90	81	81
14	85	90	94	92	91	95	100	93	93
15	87	85	80	90	90	86	82	86	86
16	86	89	92	96	99	102	105	96	95
17	76	73	71	71	73	71	69	72	72
18	70	71	73	71	80	81	83	76	76
19	72	73	75	85	81	83	85	79	79
20	70	70	69	69	72	71	71	70	70
21	77	71	65	73	78	72	66	72	72
22	91	93	94	101	105	106	108	100	97
23	63	64	64	69	69	69	69	67	67
24	71	73	76	78	74	77	80	76	76
25	75	76	77	90	89	90	91	84	84
26	91	96	101	108	121	126	130	110	98
27	91	92	94	102	109	111	112	102	97
28	65	62	59	73	83	81	78	72	72
29	62	56	50	57	57	51	45	54	54
30	83	77	71	72	76	70	64	73	73
31	80	77	74	86	84	81	78	80	80
32	65	65	65	75	75	75	74	71	71
33	69	68	67	71	79	78	77	73	73
34	77	83	90	102	105	111	118	98	93
35	95	92	88	97	104	101	97	96	96
36	83	78	72	75	79	74	68	76	76
37	91	102	113	128	128	139	150	122	99
38	87	93	99	100	101	107	113	100	97
39	61	76	91	102	98	113	127	95	90
40	61	61	61	71	66	66	66	65	65
Mean	78	78	78	84	88	88	88	83	81

a/ Computed with all sample values over 100 set = 100. Used in plotting data.

TABLE 10

Numbers of Feeders Placed on Range and Transferred to the Feedlot as Determined by the Information Feedback-Control Mechanism

Year	Variable number of feeders placed on range			Variable number of feeders transferred to feedlot				Total number of feeders placed on range and transferred to feedlot[a/]
	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	
1	466	466	466	750	799	620	629	3,998
2	690	739	787	1,079	1,008	779	750	4,816
3	668	643	619	929	931	735	735	4,530
4	444	410	376	1,061	783	466	320	3,830
5	154	133	133	713	555	375	177	3,020
6	357	305	252	471	718	575	550	3,514
7	700	609	517	864	906	731	725	4,426
8	584	476	368	802	888	630	508	4,028
9	501	474	449	973	826	541	484	4,024
10	694	436	180	983	968	479	280	3,910
11	502	782	798	1,013	974	754	741	4,682
12	344	269	193	458	708	546	494	3,406
13	400	435	469	719	750	594	641	3,904
14	603	685	770	1,089	912	726	731	4,658
15	639	567	496	900	929	679	594	4,302
16	623	677	732	990	961	744	737	4,632
17	416	372	328	889	762	479	386	3,716
18	309	338	367	687	680	506	541	3,614
19	343	373	404	720	707	528	565	3,720
20	316	306	296	793	687	449	389	3,518
21	448	331	215	704	786	519	385	3,594
22	715	740	765	1,084	1,009	749	778	4,820
23	178	186	194	640	584	407	327	3,158
24	325	375	424	870	693	464	497	3,724
25	393	416	445	645	745	609	655	3,854
26	718	795	795	1,130	1,030	795	753	4,908
27	711	735	758	1,076	1,004	776	748	4,804
28	213	159	128	291	615	504	490	3,100
29	154	128	128	711	553	373	173	3,010
30	547	435	322	954	861	524	365	3,904
31	504	448	392	805	828	589	522	3,944
32	212	208	206	552	609	437	428	3,226
33	290	273	257	571	670	493	486	3,420
34	441	562	683	782	871	709	724	4,286
35	791	719	650	1,056	993	767	744	4,760
36	555	452	349	914	866	557	419	3,956
37	704	793	793	1,121	1,026	792	751	4,890
38	626	745	793	1,059	992	769	744	4,764
39	139	419	702	516	765	669	710	3,860
40	141	137	134	611	555	391	255	3,012

a/ Number placed on range equals the variable numbers purchased in December, January, and February plus 2,600 head purchased regardless of range conditions. Number transferred to feedlot equals the variable numbers transferred in March, April, May, and June plus 1,200 transferred regardless of range conditions.

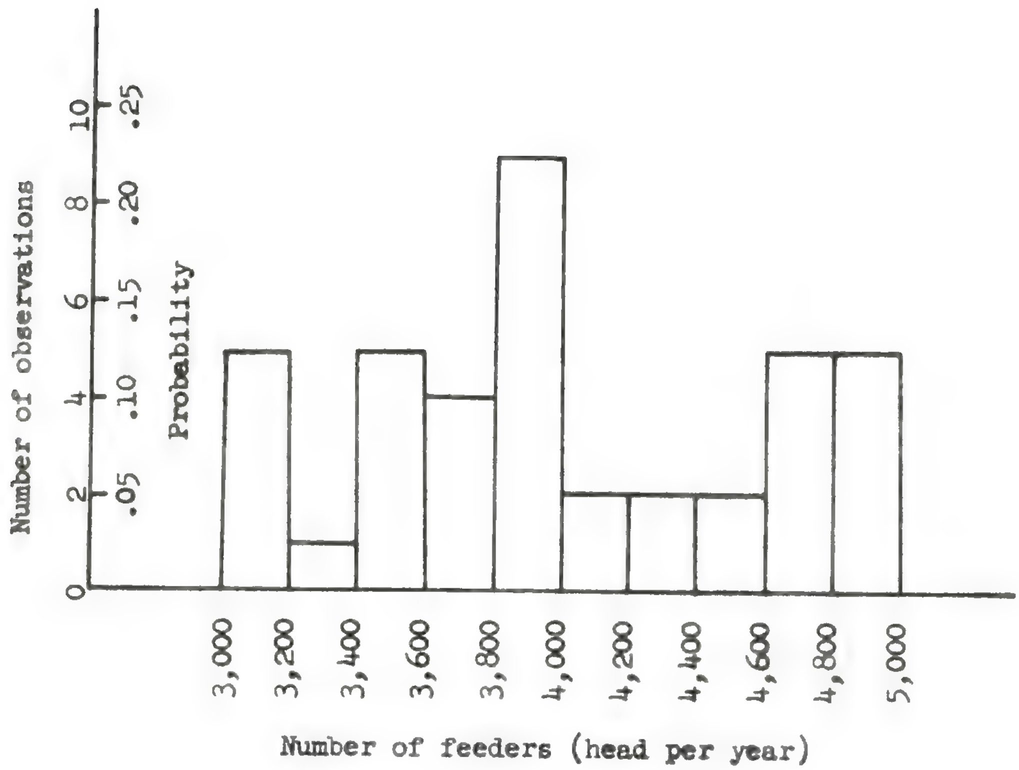

FIGURE 10. Frequency Distribution of Numbers Placed on Range and Subsequently Transferred to the Feedlot Annually over 40 Years of Simulated Range Conditions

constant rate over the February, March, and April period. However, the remaining animals on range are transferred at a variable rate during March, April, May, and June, depending on range conditions and using the decision rules outlined in previous sections. The simulated transfers for year 12 can be used to demonstrate the working of the model. In year 12, the range conditions during the months of December, January, and February were poor (72, 68, and 64, respectively) leading to relatively few animals (3,406 head) being placed on range. However, range conditions improved during March to a level of 84 by April 1. Hence, relatively few cattle were removed in March (458) and larger numbers were removed later in the spring. In a more normal year, proportionately more of the cattle are transferred earlier in the spring period.

Each run of the model for a given set of price conditions gives the same pattern of range conditions as shown in Table 9, and, therefore, gives the same pattern of numbers placed on the range and, subsequently, transferred to the feedlot. Although a different NOISE card[1/] could be used to generate a different pattern of range conditions for each run, the authors reasoned that comparisons among runs of various sets of prices were more straightforward if the underlying 40-year range environment remained constant.

Direct Buying for the Feedlot

The simulated results of the May-June buying decision for feeders purchased directly for the feedlot are summarized in Table 11. These results were obtained for each of the price expectation Models A, B, and C for each of the ten years of price conditions. The decision process for Models A, B, and C for year 1954 and for a number of other price expectation models and years (see footnote a/, Table 11) specifies buying the maximum number of feeders permitted by feedlot capacity remaining after all cattle had been transferred to the lot from the range. For example, in simulated range year 1, the total number placed on range and subsequently transferred to the feedlot is 3,998 head (Table 10). Thus, a total of 1,002 head, with 501 purchased monthly in May and June, would fill the feedlot to its capacity of 5,000 head (Table 11). In 1954, expected price relationships for Models A, B, and C were so favorable that the actual feeder price was far below the calculated "break-even" feeder price. Hence, the maximum numbers were

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1/ See section entitled "Sample Equation" in Appendix A.

TABLE 11

Total Numbers of Feeders Purchased in May and June by Year-Price Expectation Models over 40 Years of Range Conditions

Year	Year-price expectation models															
	1954 A-B-C a/		1956 A		1956 C		1957 A		1958 A b/		1959 A		1962 A		1963 B	
	May	June	May	June	May	June	May	June	May	June	May	June	May	June	May	June
1	501	501	446	459	109	150	418	472	0	0	233	269	228	352	396	424
2	92	92	83	85	20	28	78	88	0	0	43	50	42	65	74	79
3	235	235	212	219	52	71	199	225	0	0	111	128	108	167	188	202
4	585	585	529	545	130	177	495	560	0	0	277	319	270	417	469	503
5	990	990	895	922	220	300	839	948	0	0	468	539	457	706	795	852
6	743	743	671	692	165	255	629	711	0	0	351	405	343	530	596	639
7	287	287	259	267	64	87	243	274	0	0	136	156	132	204	230	247
8	486	486	439	452	108	147	412	465	0	0	230	265	224	346	390	418
9	488	488	441	455	108	148	416	468	0	0	231	266	226	348	392	420
10	545	545	493	508	121	165	462	522	0	0	258	297	252	389	438	469
11	159	159	144	148	35	48	135	152	0	0	75	87	73	113	128	137
12	797	797	721	742	177	242	675	763	0	0	377	434	368	568	640	686
13	548	548	496	511	122	166	465	525	0	0	260	299	253	391	440	472
14	171	171	155	160	38	52	145	164	0	0	81	93	79	122	138	148
15	349	349	315	325	77	106	295	334	0	0	165	190	161	249	280	300
16	184	184	166	171	41	56	156	176	0	0	87	100	85	131	148	158
17	642	642	580	598	143	195	544	615	0	0	304	350	297	458	515	553
18	693	693	627	646	154	210	588	664	0	0	328	378	321	495	557	597
19	640	640	578	596	142	194	542	613	0	0	303	349	296	456	514	551
20	741	741	670	691	165	225	628	710	0	0	351	404	343	529	595	638
21	705	705	636	655	156	213	596	674	0	0	333	383	325	502	565	606
22	90	90	82	84	20	27	76	86	0	0	43	49	42	64	72	78
23	921	921	833	858	205	279	781	882	0	0	436	502	426	657	740	793
24	638	638	577	594	142	194	540	611	0	0	302	348	295	454	512	549
25	573	573	518	534	127	174	485	549	0	0	271	312	265	409	460	493
26	46	46	41	43	10	14	39	44	0	0	22	26	21	33	37	40
27	98	98	89	92	22	30	83	94	0	0	47	54	46	71	79	85
28	950	950	859	885	211	288	805	910	0	0	450	518	439	677	763	818
29	995	995	899	927	221	302	843	953	0	0	470	542	460	710	799	856
30	548	548	495	511	122	166	464	525	0	0	259	298	253	391	440	472
31	528	528	478	492	117	160	448	506	0	0	250	288	244	377	424	455
32	887	887	801	826	197	269	751	849	0	0	420	483	410	632	712	763
33	790	790	714	736	176	240	670	757	0	0	374	430	365	564	634	680
34	357	357	323	332	79	108	302	342	0	0	169	195	165	255	286	307
35	120	120	108	112	27	36	102	115	0	0	57	65	56	86	96	103
36	522	522	472	487	116	159	443	500	0	0	247	285	241	373	419	450
37	55	55	50	51	12	17	46	52	0	0	26	30	25	39	44	47
38	118	118	106	110	26	36	100	113	0	0	56	64	55	84	95	101
39	570	570	515	110	127	173	483	546	0	0	270	311	264	408	458	491
40	994	994	899	926	221	302	843	952	0	0	471	542	460	709	798	856

a/ The following year-price expectation models gave the same sequence of May-June feeder purchases: 1955 A-B-C, 1956 B, 1957 B-C, 1958 B-C, 1959 B-C, 1960 A-B-C, 1961 A-B-C, 1962 B-C, and 1963 A.

b/ The 1963 C model also gave zero May-June feeder purchases.

purchased. In 1958, on the other hand, price expectations using Model A were so unfavorable that the actual feeder price was above the calculated "break-even" price and no cattle were purchased.

The May-June buying decision rules are illustrated by considering 1956, year 2, for each of the three price expectation Models A, B, and C. In Model A, where the expected slaughter cattle price is equal to the price received the previous year, the comparison of the actual feeder price with the calculated "break-even" price gives buying rate adjustment constants of approximately 0.86, 0.94, and 0.91 on May 1, June 1, and July 1, respectively. A buying rate constant of 1.0 implies buying the maximum number if the actual price is $3.00 or more below the "break-even" price. Thus, for example, the buying rate adjustment constant of 0.86 on May 1 indicates that the actual feeder price is $2.58 below the calculated "break-even" price ($3.00 x 0.86 = $2.58). The average buying rate adjustment constants in May and June are 0.90 and 0.925, leading to purchases of 83 and 85 head in those two months. That is, the maximum number to buy is 92 each month; 92 x 0.90 = 83 and 92 x 0.925 = 85.

Using price expectation Model B in 1956 leads to a calculated "break-even" feeder price more than $0.25 per hundredweight above the actual feeder price. Hence, the buying rate adjustment constant is 1.0 and the maximum number of 92 head are purchased monthly in May and June.

Price expectation Model C for 1956 leads to buying rate adjustment constants of 0.10, 0.34, and 0.26 on May 1, June 1, and July 1, respectively, or an average of 0.22 during May and 0.30 during June. In this case, 20 head are purchased in May (92 x 0.22 = 20) and 28 are purchased in June (92 x 0.30 = 28).

In 22 out of the 30 year-price expectation models the maximum number of cattle were purchased (Table 11). In two situations, none were purchased and in the other six cases, intermediate numbers were bought. Thus, in general, prices were sufficiently favorable over most of the ten-year period so that expected returns from the cattle purchased in May and June exceeded variable costs by a margin encouraging maximum or near-maximum purchases directly for the feedlot.

Simulated Net Income Levels and Distributions

The major objectives defined by the management of the range-feedlot operation related to net income. As discussed earlier, the two major criteria adopted in judging the "success" of the various simulations in achieving the objectives

of management are: (1) Increases in the level of average net income and (2) reductions in the variability of net income. The first subsection below defines the components of net income used in this report. The second subsection presents the results of the initial simulation over the 400 range-price observations using management's price expectation Model A.

Net Income Defined

The components of revenue and cost making up net income are best identified by reference to the series of Tables C-4 through C-21 in Appendix C. Revenue from the operation comes mainly from cattle sales, with minor amounts from sales of barley and manure. Barley production was assumed to vary in accordance with weather and range conditions.[1/] Because rolled barley is used in feeding, the barley produced is sold and rolled barley repurchased from a feed company. The two major cost items in the business are the cost of the feeder cattle and feed costs, totaling a million dollars in most years. The total fixed cost of $193,000 described earlier (Table 2) is a third large cost item. Direct nonfeed expenses in the lot and interest on operating capital are the remaining cost items. Both are functions of the number of cattle included in the operation. Interest may not be entirely a cash cost because the operation often operates partly on its own funds rather than borrowed funds. Finally, it should be recognized in interpreting the net income figures that salaries of $10,000 have been paid to each of the three members of management as part of the $193,000 fixed cost of the operation. Thus, even with a net income of zero, $30,000 is available as compensation to management.

Simulation Results -- Model A

The initial computer runs of the model represent an attempt to approximate as closely as possible the level and distribution of net incomes which would occur

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1/ Average production per year is 1 ton per acre or 650 tons for the entire 650 acres in barley. Since weather affects range conditions and barley similarly, total barley production (P) was assumed to be related to the range index (R) as follows: Mean barley production (P = 650 tons) is associated with mean range conditions (R = 78); high range conditions (R = 95) are associated with mean barley production +16 percent (P = 754); low range conditions (R = 61) are associated with mean barley production -16 percent (P = 546). The range in yield variability of ± 16 percent is equal to two standard deviations of barley yields as estimated by: Carter, H. O., and G. W. Dean, "Income, Price, and Yield Variability for Principal California Crops and Cropping Systems," Hilgardia, Vol. 30, No. 6, October 1960, p. 215. The resulting function is: $P = \overline{173 + 6.12R}$, $61 \le R \le 95$. If $R > 95$, $P = 754$; if $R < 61$, $P = 546$.

over a long period of time for the range-feedlot operation if management used current decision procedures under price conditions similar to those of the past ten years. It is assumed for these initial runs that expected prices of May and June feeders are equal to those received in the previous year (price expectation Model A described earlier).

A summary of parameters of the distributions of net incomes are shown in Table 12. As shown by the variation in means (or median) from one year to another, a major factor in setting the general level of income is the level of prices (primarily cattle prices). The mean income varied from highs of $60,320 and $59,450 in 1954 and 1957, respectively, to lows of -$23,510 in 1961 and -$39,360 in 1963. These good and bad years conform rather closely to the general experience of most cattle feeders. The experience of the particular case study operation in 1962 and 1963 (the period when records were available) was remarkably close to the simulated results,[1/] with excellent profits in 1962 and large losses in 1963.

Given any particular set of prices, considerable variation in income still is possible due to variability in range conditions. The standard deviations, range and extreme values (Table 12) emphasize the great degree of variability due to range conditions for given prices. For example, at 1958 prices, the mean income was $14,430 but incomes varied from -$87,280 to $119,080, depending on the range conditions. The extreme values show that, even with the most favorable price relationships (as in 1957), it is possible to lose money (up to -$25,580) if range conditions are poor; conversely, even if prices are extremely unfavorable (as in 1963), it is possible to make sizable good profits (up to $48,910) if range conditions are favorable.

In general, the measures of dispersion (standard deviation and range) are of roughly the same magnitude for each of the ten sets of prices; hence, range conditions cause about the same absolute amount of variation in net income regardless of the price level. A more graphic visualization of the simulated net income distributions is given by the plotted results in the frequency distributions of Figure 11. The distributions of net incomes caused by variation in range conditions are normally distributed as indicated by a chi-square test for

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1/ Range conditions in 1962 and 1963 were close to average and, therefore, the major variable affecting income levels was prices.

TABLE 12

Comparison among Simulated Distributions of Net Incomes over 40 Years of Range Conditions, at Each of Expected Prices for Years 1954-1963, Using Price Expectation Model A

Prices for year	Parameters of net income distributions					
	Median	Mean	Standard deviation	Range	Extreme values	
					Low	High
	dollars					
1954	56,170	60,320	36,640	144,930	- 6,800	138,130
1955	- 590	1,130	36,780	147,220	- 70,050	77,170
1956	26,620	30,590	33,840	134,120	- 34,000	100,120
1957	58,380	59,450	43,600	178,170	- 25,580	152,590
1958	3,950	14,430	49,920	206,360	- 87,280	119,080
1959	20,020	26,910	45,390	183,490	- 61,650	121,840
1960	8,780	7,640	43,020	180,970	- 79,140	101,830
1961	-20,460	-23,510	38,950	188,200	-134,140	54,060
1962	40,710	43,050	42,840	178,770	- 43,000	135,770
1963	-38,630	-39,360	40,120	161,810	-112,900	48,910
10 year accumulated	16,660	18,110	51,500	286,730	-134,140	152,590

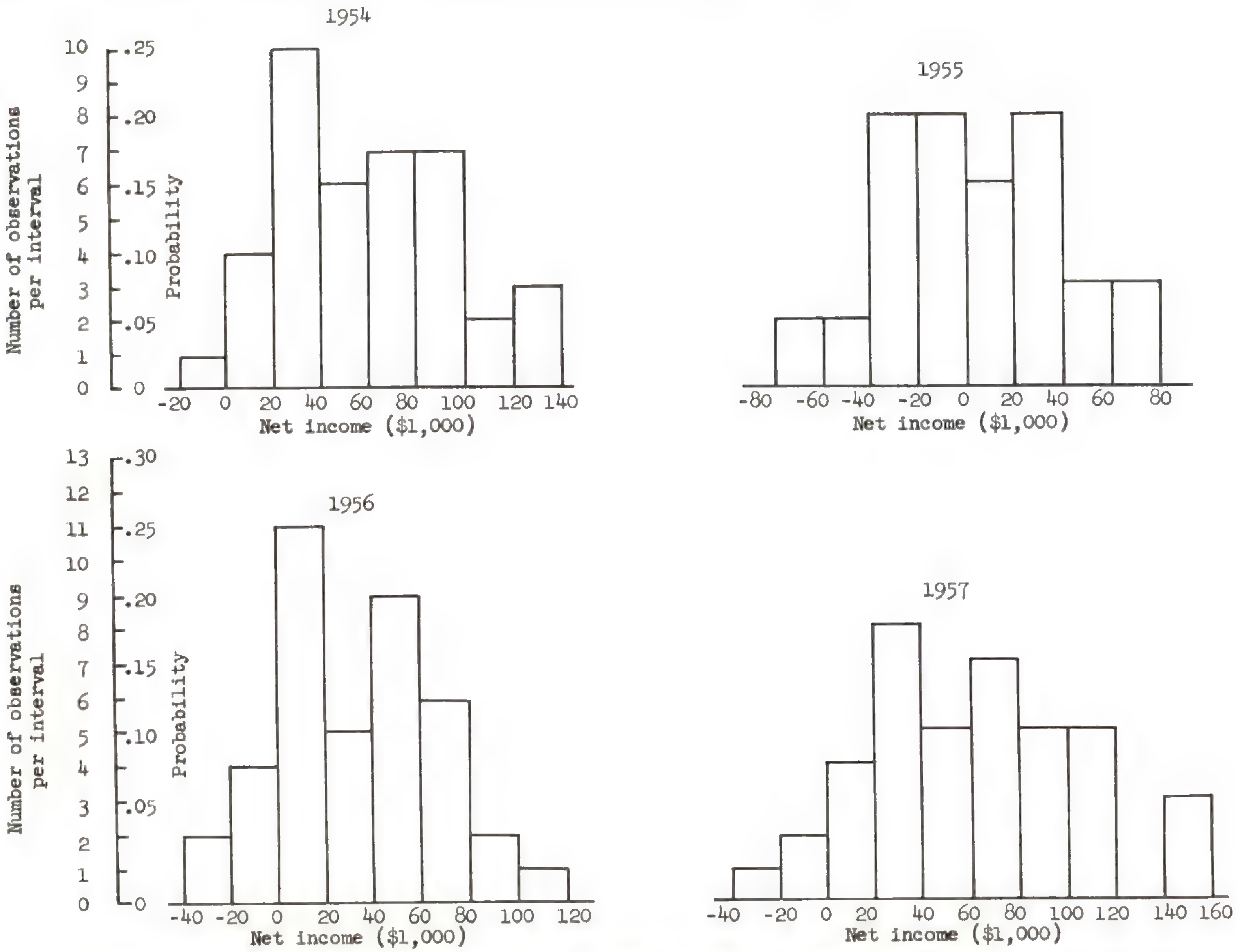


FIGURE 11. Distributions of Net Farm Income from Variation in Range Conditions, under Actual Price Relationships Annually, 1954-1963: Last Year's Price Expected (Model A)

FIGURE 11 continued.

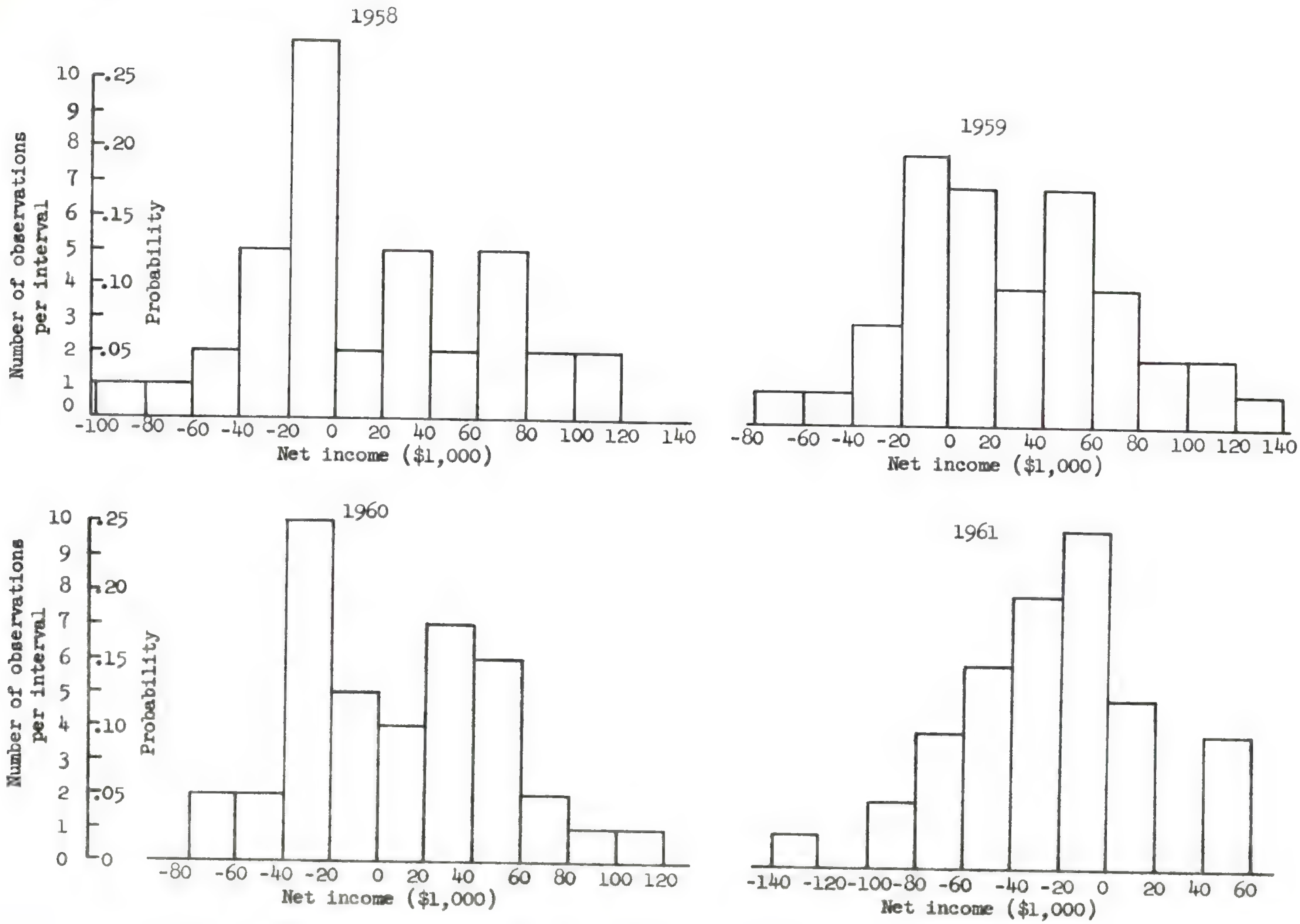
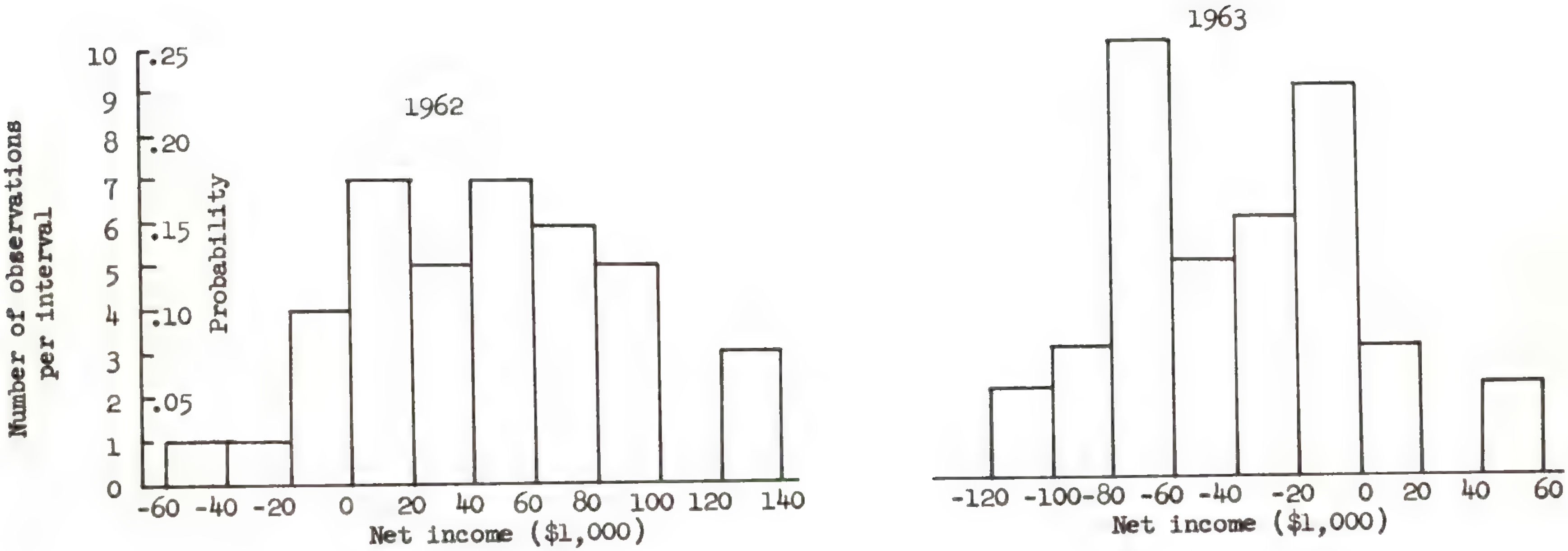


FIGURE 11 continued.



goodness of fit.[1] Another indication of the normal distribution is the closeness of the median and mean in Table 12 for each of the ten sets of prices.

Although range conditions cause considerable dispersion of net income, the major factor affecting the general level of income is the level of cattle and feed price relationships summarized in Table 13. The disasterous results in 1963 were caused by unfavorable cattle margins and high feed prices. In 1961, the poor results were due to extremely unfavorable margins between the prices of calves purchased for the range and prices of slaughter cattle. A favorable year, such as 1954, was due to extremely large price margins, even though feed prices also were high. Another favorable year was 1957 which resulted from a combination of favorable margins and low feed prices. In 1958 and 1959, the results were reasonably favorable because the general cattle price level was high even though margins were negative.[2]

Figure 12 shows a fairly close linear relationship between range conditions and simulated net incomes ($r^2 = 0.65$) at 1954 prices. Similar results for all ten price situations, 1954-1963, are shown in Table 14. These results illustrate again that net income is dependent on the combination of range conditions and prices and not on either alone. Excellent range conditions can assure profits under any of the price situations observed. However, poor range conditions mean losses regardless of price. Of course, for any given range condition, the higher the price, the more favorable the outcome.

Improvement of System Performance Through Alternative Price Expectation Models

The above section presented the simulation results for the range-feedlot system using present management decision procedures, including a price expectation model in which slaughter prices are expected to approximate those received in the previous year (Model A). As stated earlier, one area in which management decisions might be improved is in the formulation of price expectations. To

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1/ For each of the years 1954 through 1963 the chi-square test indicated that the simulated distribution was not significantly different from a normal distribution at the five percent significance level.

2/ The higher the absolute price level, the less price margin needed to obtain the same income: Petit, J. A, and G. W. Dean, Economics of Farm Feedlots, Berkeley: University of California, Agricultural Experiment Station Bulletin No. 800, May 1964, pp. 21-26.

TABLE 13

Feed Prices, Cattle Prices, and Margins Used in Simulation

Year	Annual average feed cost per head per day	Average price, steer calves 300-500 pounds, Oct.-Mar.	Average price, feeder steers 500-800 pounds, May-June	Average price, slaughter steers 900-1,100 pounds, May-Sept.	Margin, slaughter price-calf price	Margin, slaughter price-feeder steer price
	dollars	dollars per cwt				
1954	0.622	20.22	20.94	23.55	3.33	2.61
1955	0.595	19.54	20.11	22.51	2.97	2.40
1956	0.590	18.56	18.02	21.21	2.65	3.19
1957	0.567	21.11	20.42	23.00	1.89	2.58
1958	0.555	28.77	26.50	26.69	-2.08	0.19
1959	0.577	30.02	28.06	27.66	-2.36	-0.40
1960	0.550	27.02	25.12	25.91	-1.11	0.79
1961	0.575	26.87	22.56	23.58	-3.29	1.02
1962	0.589	27.44	24.58	26.89	-0.55	2.31
1963	0.613	26.68	23.94	24.29	-2.39	0.35

Source: Appendix Tables C-1 and C-2.

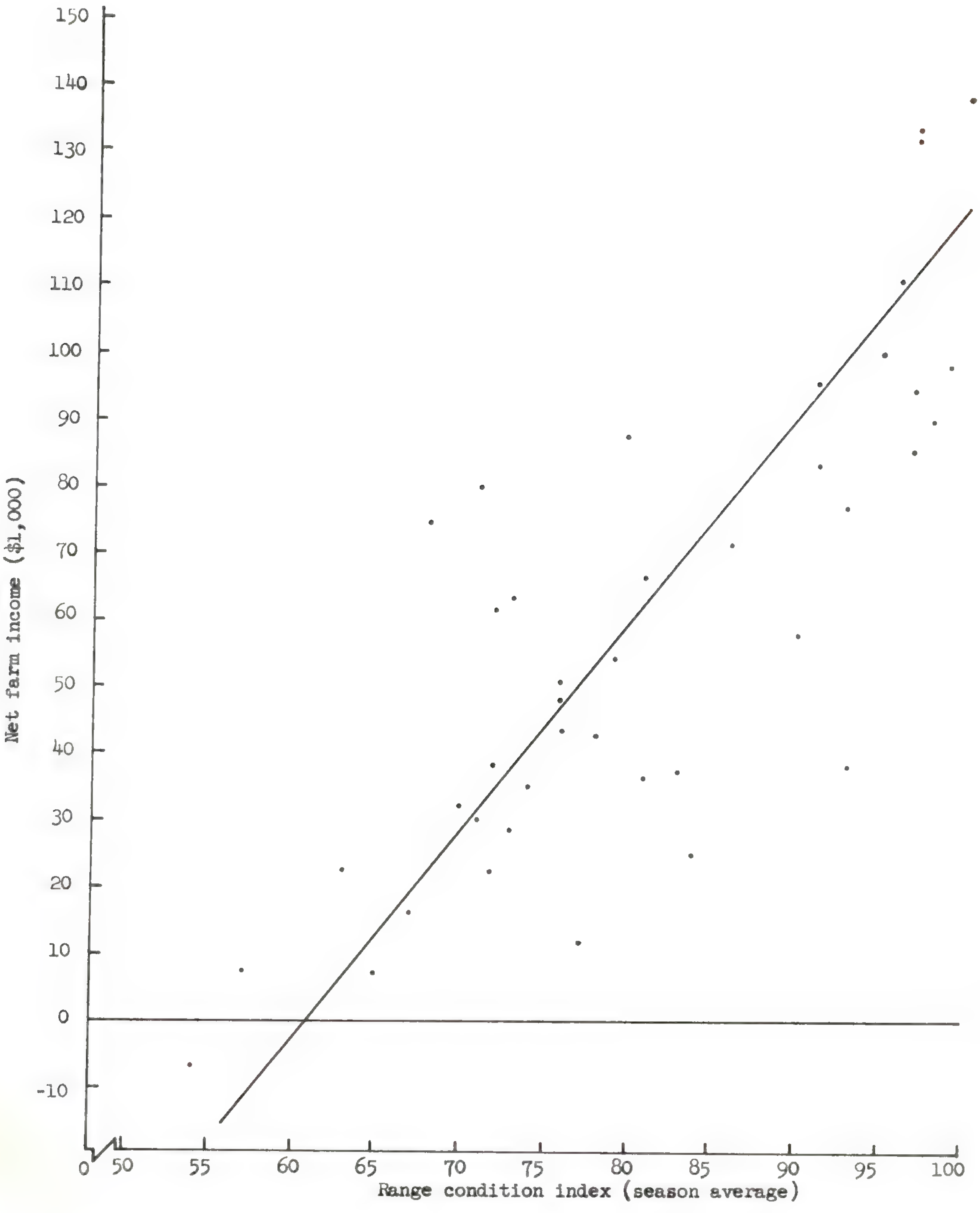


FIGURE 12. Relationship of Range Condition to Net Income; 1954 Prices

TABLE 14

Summary of Linear Regressions of Net Farm Income on Index of Range Conditions a/

Year	Intercept $\hat{a}$	Slope b/ $\hat{b}$	Standard error of b s_b	t-value for b	Correlation coefficient r^2
1954	-136.60	2.41	0.29	8.32	0.65
1955	-193.86	2.40	0.30	8.09	0.63
1956	-148.35	2.20	0.27	8.05	0.63
1957	-170.08	2.82	0.36	7.86	0.62
1958	-237.75	3.12	0.43	7.38	0.59
1959	-140.52	2.06	0.50	4.10	0.31
1960	-204.11	2.61	0.39	6.75	0.55
1961	-200.56	2.18	0.38	5.77	0.47
1962	-138.54	2.20	0.40	5.45	0.44
1963	-232.05	2.36	0.36	6.60	0.53

a/ Equations of the form: $Y = a + bX$.

b/ A series of t-tests showed no significant differences at the five percent level between all pairs of b's.

identify the maximum potential improvement obtainable through formulation of price expectations, Model B was run in which it was assumed that management has perfect knowledge of slaughter prices. Finally, alternative price expectation Model C was developed in which management based price anticipations on the current price adjusted for the historical seasonal variation between buying and selling dates. This is a simple model which management could reasonably be expected to adopt if improvements warranted its use.

The simulated performance of the system is summarized below for each of the three price expectation models. In general, Model B should provide the highest incomes which can be expected, since it is impossible to improve on a "perfect" price forecast. It is used primarily as a basis for comparison with Model A representing current practices and Model C representing an attempt to improve one component of the decision-making process.

A comparison among net incomes for the three price expectation models is shown in Table 15. In 1954, 1955, 1960, and 1961, the results of all three models were the same. In these years, the expected slaughter prices were so favorable under each of the three models that the actual feeder prices, when compared to the calculated break-even feeder prices, led to purchase of the maximum number of feeders permitted by the remaining feedlot capacity.

In 1957, 1958, 1959, and 1962, Model C led to the same buying decision as Model B, whereas Model A led to a decision to buy less than maximum numbers. In each of these cases, the alternative Model C was an improvement over the original Model A when judged by both of the criteria selected, i.e., Model C had both a higher mean income and a lower standard deviation and range than Model A. Substantial improvements in mean income are obtained from Model C compared with A in 1958 and 1962. However, in 1957 and 1959, the differences are slight.

In 1956 and 1963, Models A, B, and C each led to a different decision on numbers purchased. In 1956, Model A resulted in higher incomes than Model C. However, in 1963 the situation was reversed.[1/]

- -

1/ Surprisingly, in 1963, certain price Model B led to slightly lower mean income than Model C. This unexpected result was apparently due to the fact that the equations for computing "break-even" feeder prices deliberately omitted interest on the operating capital as a variable cost. When interest is added as a cost, the additional feeders purchased in Model B are unprofitable. In Model C no feeders are purchased.

TABLE 15

Comparison among Simulated Distributions of Net Incomes for 40 Years of Range Conditions, Using Three Alternative Price Expectation Models for Years 1954-1963

Year	Price expectation model a/	Parameters of net income distribution					
		Median	Mean	Standard deviation	Range	Extreme values: Low	Extreme values: High
		dollars					
1954	A-B-C	56,170	60,320	36,640	144,930	- 6,800	138,130
1955	A-B-C	- 590	1,130	36,780	147,220	- 70,050	77,170
1956	A	26,620	30,590	33,840	134,120	- 34,000	100,120
	B	27,270	31,240	32,740	133,360	- 32,420	100,940
	C	17,070	21,600	38,770	147,910	- 49,120	98,790
1957	A	58,380	59,450	43,600	178,170	- 25,580	152,590
	B-C	59,800	60,650	42,910	174,560	- 23,120	151,440
1958	A	3,950	14,430	49,920	206,360	- 87,280	119,080
	B-C	14,400	22,250	48,200	198,190	- 72,110	126,080
1959	A	20,020	26,910	45,390	183,490	- 61,650	121,840
	B-C	19,330	27,210	43,630	182,420	- 60,950	121,470
1960	A-B-C	8,780	7,640	43,020	180,970	- 79,140	101,830
1961	A-B-C	-20,460	-23,510	38,950	188,200	-134,140	54,060
1962	A	40,710	43,050	42,840	178,770	- 43,000	135,770
	B-C	53,430	51,580	39,050	164,830	- 27,160	137,670
1963	A	-38,630	-39,360	40,120	161,810	-112,900	48,910
	B	-46,580	-38,860	41,110	159,020	-109,610	49,410
	C	-29,140	-38,760	43,970	151,430	-100,200	51,230
10 year accumulated	A	16,660	18,110	51,500	286,730	-134,140	152,590
	B	22,375	19,960	51,400	285,580	-134,140	151,440
	C	18,890	19,850	50,500	285,580	-134,140	151,440

a/ A = Last Year Price Expected
B = Certain Price Expected
C = Seasonal Price Expected.

Figures 13 to 18 provide a pictorial comparison of the income distributions from the alternative price expectation models in those years where differences among models occurred. The distributions for 1954, 1955, 1960, and 1961 shown in Figure 11 apply to all models because no differences among models occurred in those years.

The bottom portion of Table 15 and Figure 19 show an overall comparison of Models A, B, and C for the entire 400 price-range conditions simulated. Model C represents an improvement over Model A using both criteria specified earlier: Model C has (1) the greater mean income and (2) the smaller variation as measured by standard deviation and range. In fact, Model C has a smaller standard deviation than Model B. However, the magnitude of the improvements from C compared to A are relatively slight.

Evaluation of Results

The results of this section would seem to indicate that relatively naive price forecasting models for the May-June buying decision give results not differing greatly from those of a perfect knowledge model. In particular, for the short-run price forecast (four months ahead), the seasonally adjusted May-June slaughter price does exceptionally well. However, even a perfect forecasting model would neither substantially increase the mean income nor reduce the variance of income. An obvious question is whether the buying decisions for the cattle put on range could be improved by making their purchase also a function of price. This possibility could be examined by simulation procedures.

Another approach to improving the overall performance would be to separate the income, costs, and returns for the range and feedlot sectors. One hypothesis suggested by the results is that the range sector is relatively profitable and the feedlot unprofitable. Also, in buying cattle for the range, it may be profitable to overstock and feed hay and other supplemental feeds to make up range deficits. Such a decision might tend to reduce fluctuations in incomes as well as raise the level of income.

If, however, simulation shows that both range and feedlot operations are profitable and that the buying decisions cannot be markedly improved, then the conclusion is that it is virtually impossible to reduce the wide fluctuations in incomes due to the exogenous variables of range conditions and prices. This is a conclusion of considerable importance. The manager is then forced to accept

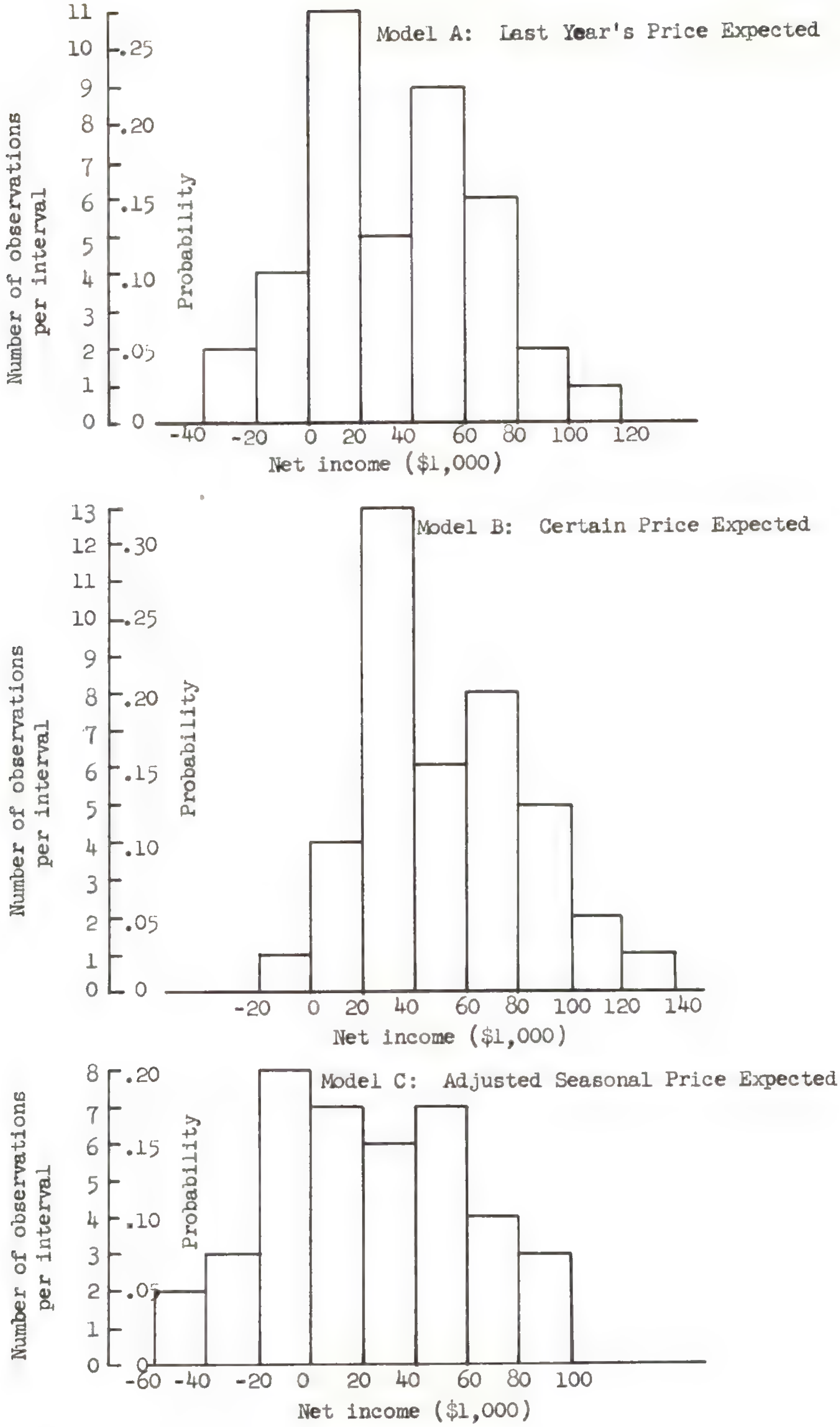
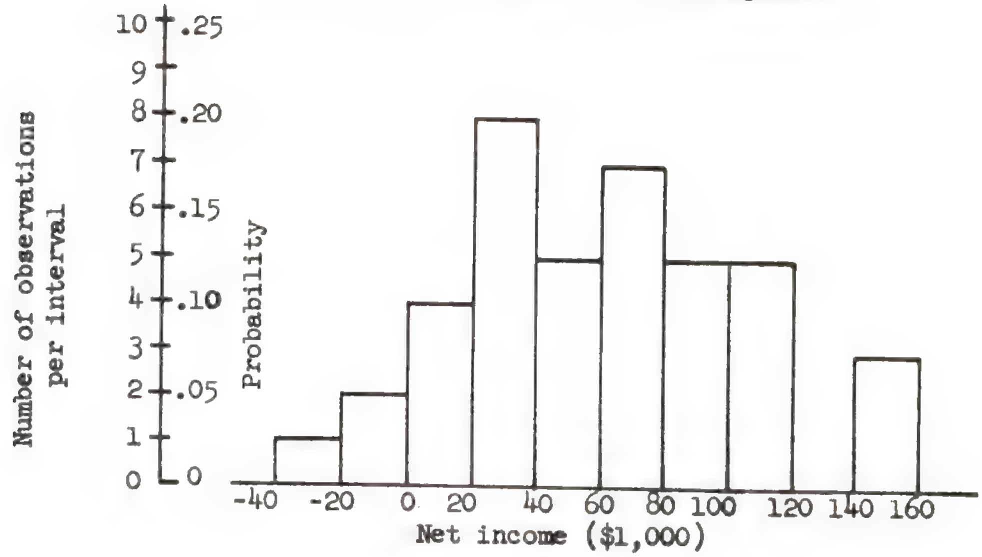


FIGURE 13. 1956: Comparison of Distribution of Net Farm Income from Alternative Price Expectation Models

Model A: Last Year's Price Expected



Model B: Certain Price Expected
Model C: Adjusted Seasonal Price Expected

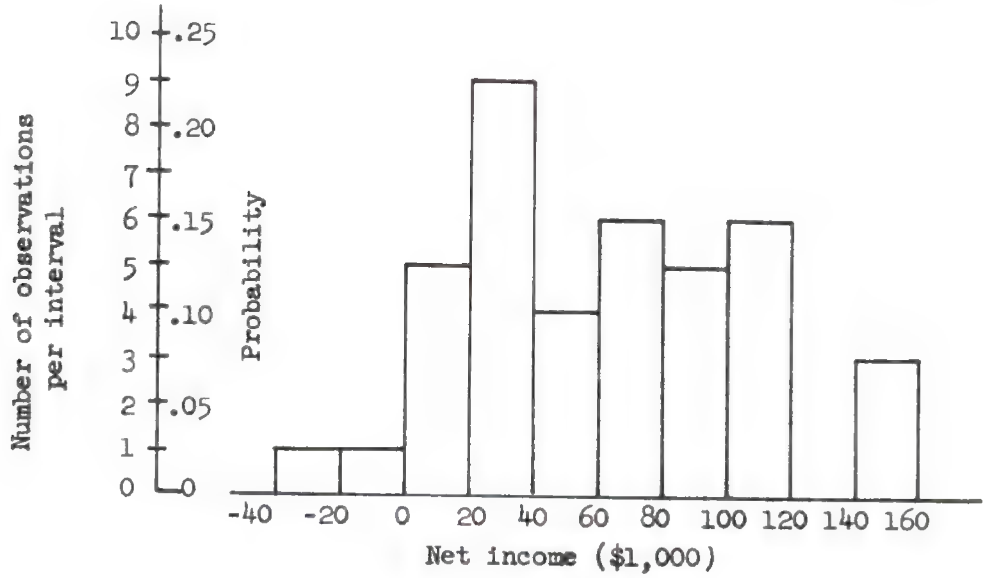
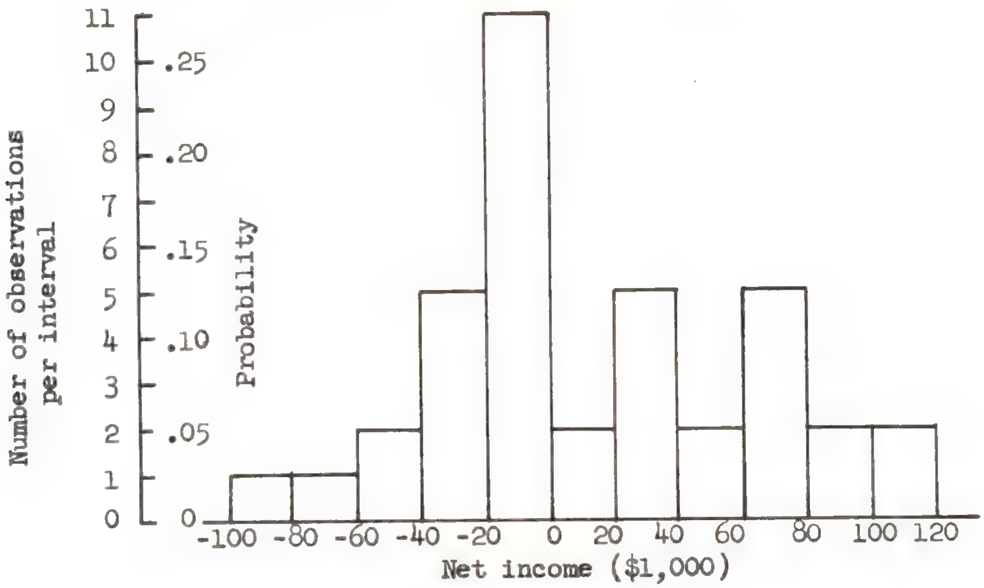


FIGURE 14. 1957: Comparison of Distribution of Net Farm Income from Alternative Price Expectation Models

Model A: Last Year's Price Expected



Model B: Certain Price Expected
Model C: Adjusted Seasonal Price Expected

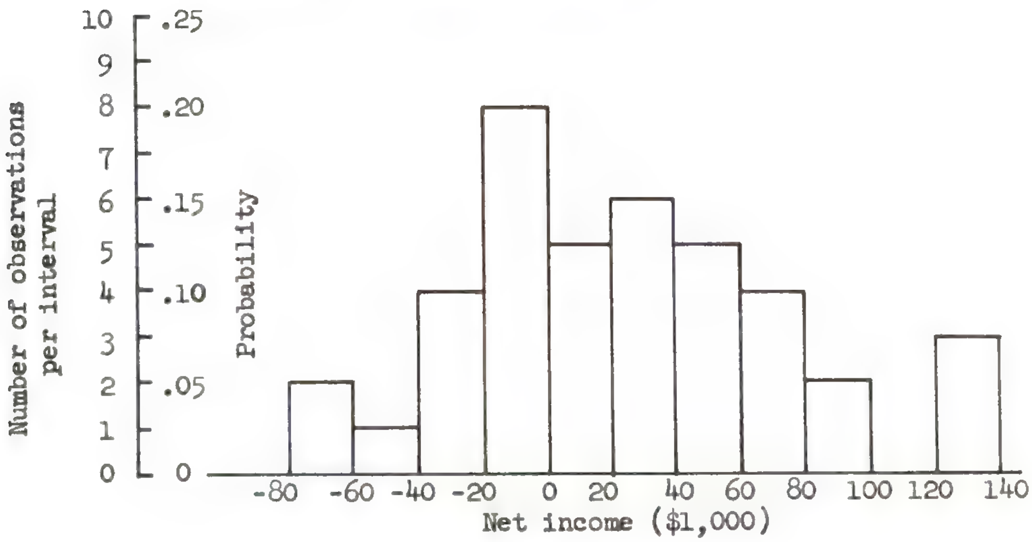
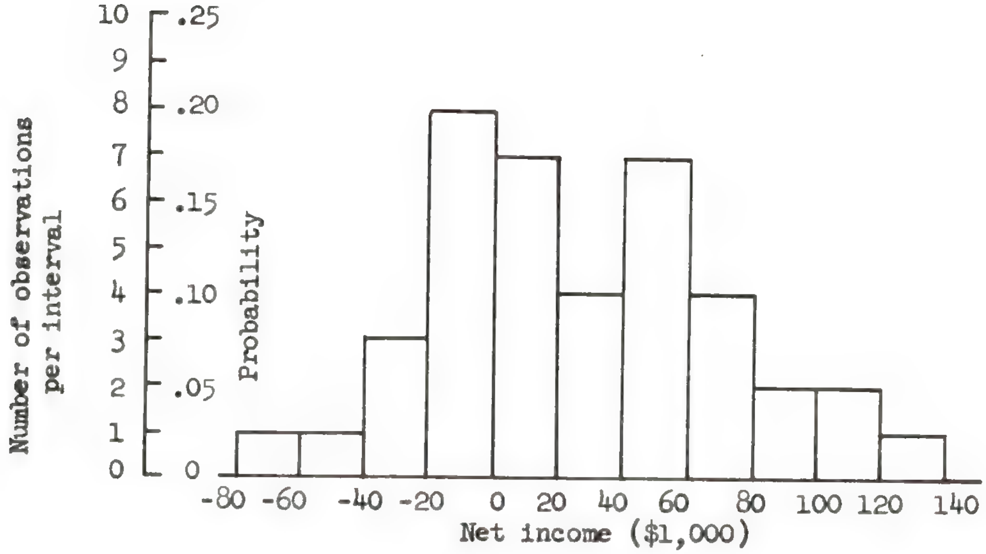


FIGURE 15. 1958: Comparison of Distribution of Net Farm Income from Alternative Price Expectation Models

Model A: Last Year's Price Expected



Model B: Certain Price Expected
Model C: Adjusted Seasonal Price Expected

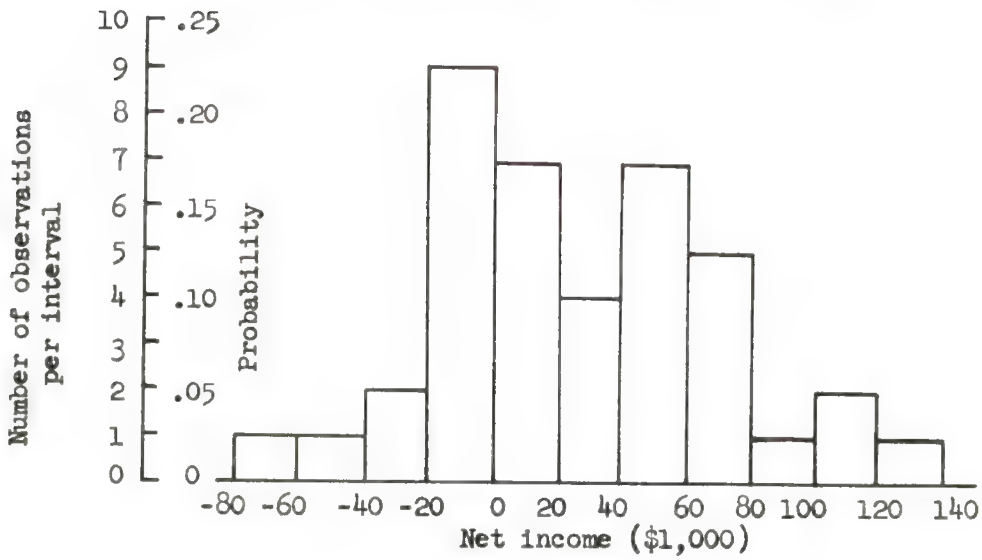
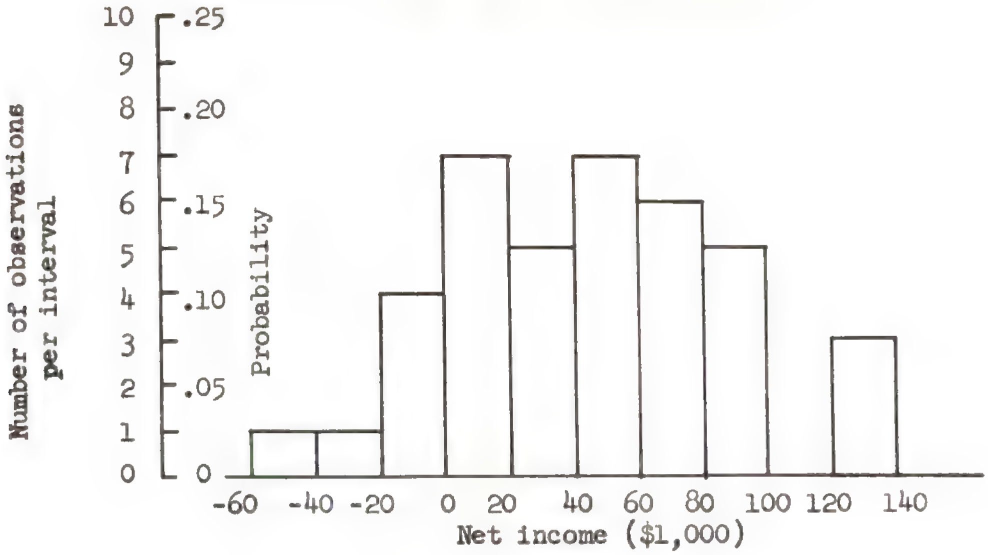


FIGURE 16. 1959: Comparison of Distribution of Net Farm Income from Alternative Price Expectation Models

Model A: Last Year's Price Expected



Model B: Certain Price Expected
Model C: Adjusted Seasonal Price Expected

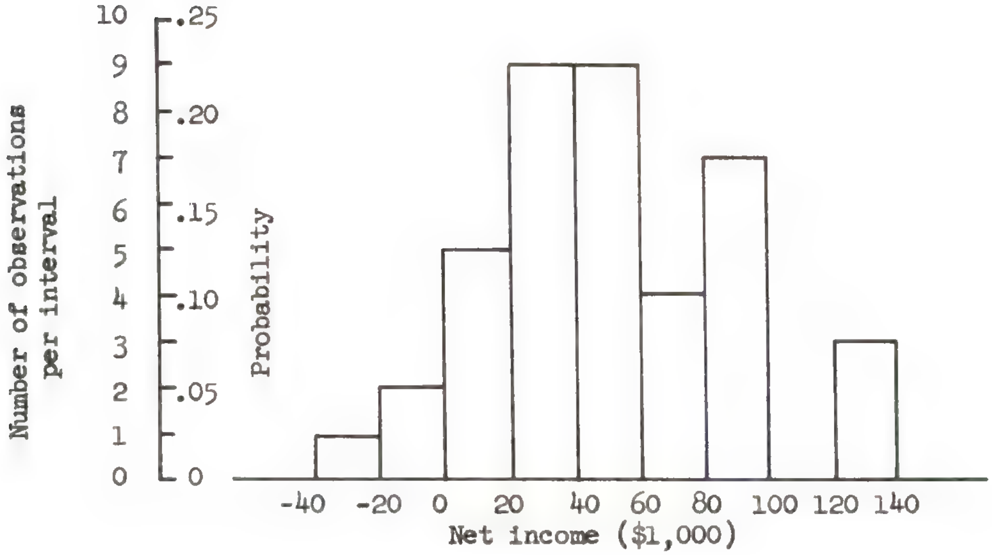


FIGURE 17. 1962: Comparison of Distribution of Net Farm Income from Alternative Price Expectation Models

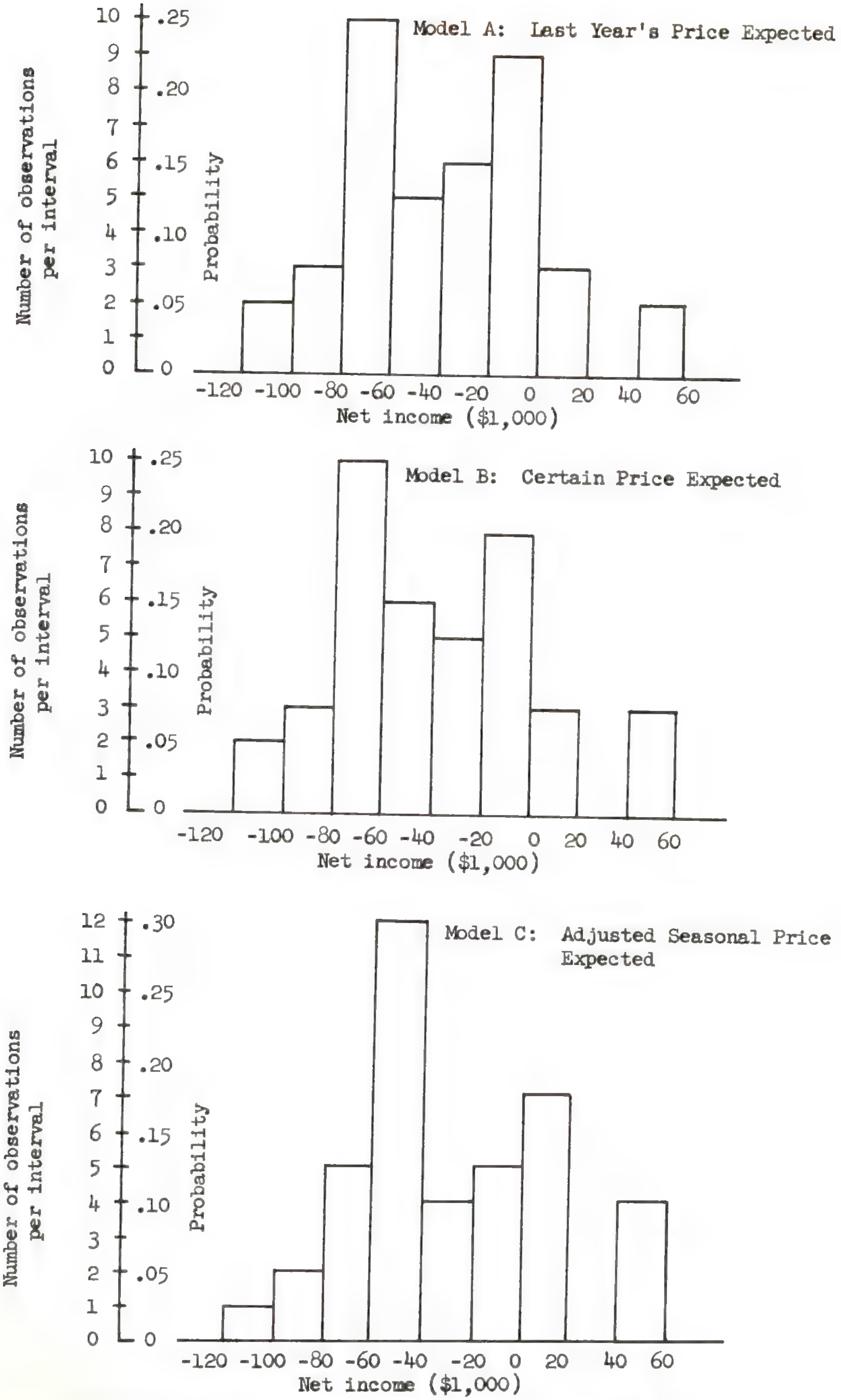


FIGURE 18. 1963: Comparison of Distribution of Net Farm Income from Alternative Price Expectation Models

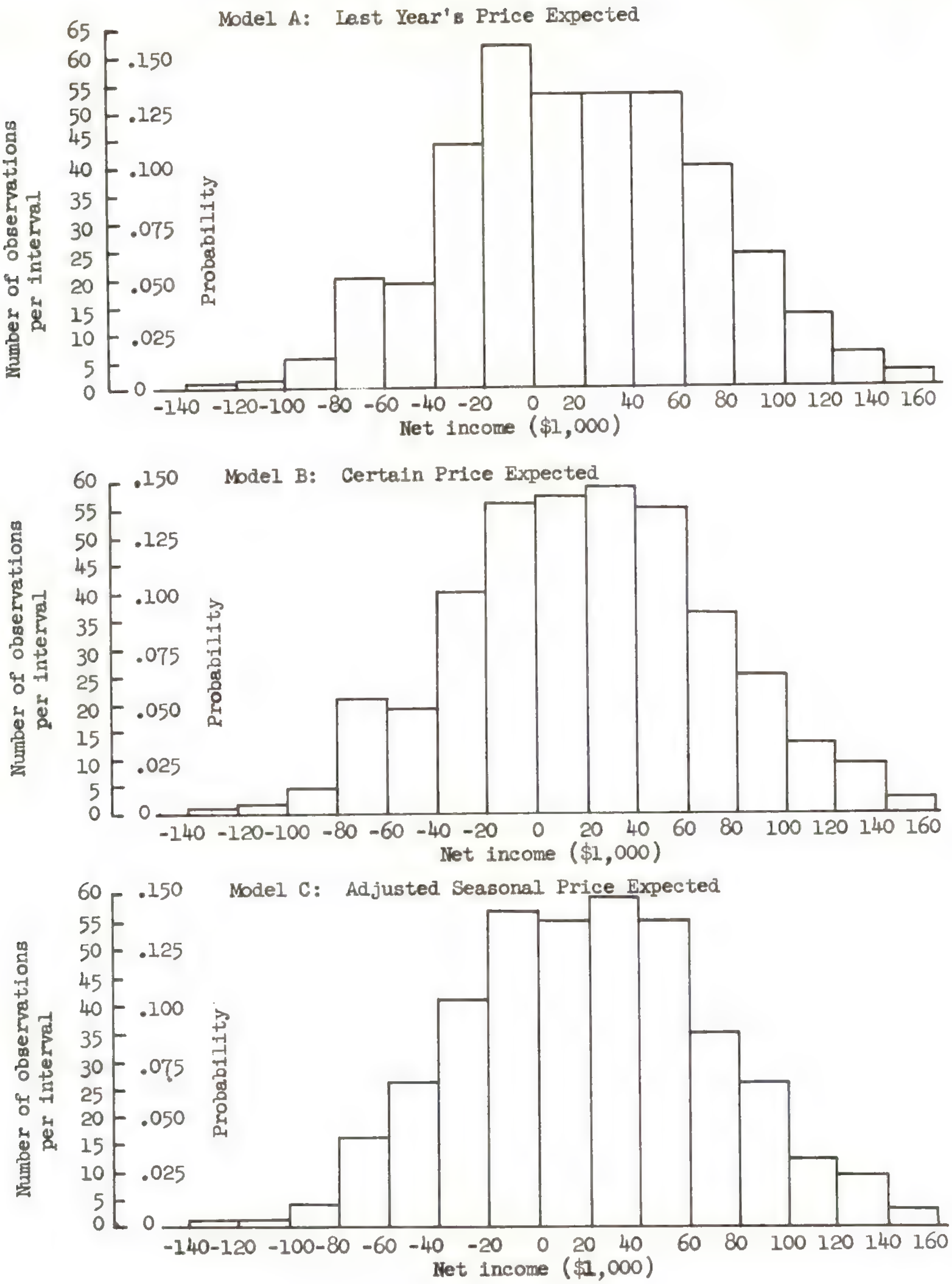


FIGURE 19. Distribution of Net Income over All 400 Price-Range Condition Observations for Price Expectation Models A, B, and C

wide variability as unavoidable. He might therefore be led to investigate possibilities to improve the technical efficiency of the firm -- better feed conversion, faster gains, lower costs, etc. Included as possible improvements would also be development of the management's skill in buying and selling cattle on the most favorable terms as to price and quality, given the general level of exogenous cattle prices.

PART V

IMPLICATIONS OF STUDY

This report has shown the methodology of simulating the decision-making environment of a range-feedlot operation and has presented the results of management's decision-making processes within this simulated environment. The environment, as is the case for most firms in agriculture, contains two components about which farm managers have imperfect knowledge. First and foremost is weather. In the range-feedlot operation, the growth of the range grass and subsequent feed supply are affected by rainfall and other climatic conditions which occur from October through June. Second, by no means of lesser importance than weather, is the price component. Prices of outputs and inputs are difficult for farm managers to forecast when decisions must be made several months before the final outcome is definite. In the range-feedlot operation, buying decisions regarding feeder animals to fill the feedlot in May and June seemed to be a crucial point at which the profits of the firm were particularly subject to the forecasting accuracy of the management.

The particular methodology used in the study was that of industrial dynamics. The main concept of industrial dynamics is the information feedback mechanism involved in decision making, and the time dependent interrelations among the components of the system. An information-feedback mechanism is one in which the environment leads to a decision that results in action which in turn affects the environment. It is a concept with which everyone is familiar from his contact with such biological and physical systems as body temperature control and the temperature control of a thermostat. However, as a concept, it has been given little attention in farm management research. In this study, the information-feedback concept was used in formulating the decisions to buy feeders for the range and to transfer animals to the feedlot. As information became available to the

management on range conditions, the rate of transfer to the feedlot controlled the environment in which subsequent decisions would be made. This rather obvious description of what most farm managers do in arriving at stocking rates for pasture and range has been largely outside the reach of techniques of farm management research to date.

The time dependent interrelations among the decisions which management makes in an operation such as the one reported here is another feature of reality which present research techniques have not fully recognized. Dynamic programming and linear programming have been applied to some simplified problems of decision making through time. However, the complexities of reality in even such a small operation as reported here present a tremendous challenge to these techniques. Forrester has made the point that reality may be so complex that the basic concept of optimizing inherent in "programming" techniques may be meaningless. Obviously, "programming" has a definite place in the economist's kit of tools; but, the economist must recognize when he has sacrificed the essence of the problem for the simplicity of the tool.

Although maximizing and minimizing decision processes can be built into a simulation, the experimental approach was taken by this study toward understanding the dynamics of the system as a whole. We attempted to describe the basic dynamic structure of the range-feedlot operation so that tests could be performed on hypothesized improvements in the system. This study has concentrated on a farm management problem which has received considerable verbal and cursory attention in the field -- the formulation of appropriate expectation models for input and output prices. Research in this area has been hampered by the enormous task of testing expectation models in an environment which even vaguely resembles reality. The experimental approach of this study has shown how various expectation models interact with the dynamics of reality and how the level and stability of income obtained can be used as a criterion of choice among the models. Thus, an approach has been demonstrated which may prove to be a major step forward in the study and testing of expectation models.

Simulation is made feasible only by two technological developments in the past 15 years; namely, digital computers and a flexible easily understandable simulation language. In the area of calculations, the digital computer has reduced the cost of arithmetic computations by a factor of ten thousand. In the foreseeable future this will be reduced still further. An estimate by one of

the founders of digital computers, Jay W. Forrester, places the cost reduction in the area of one hundred thousand. This fact, in itself, places every farm management researcher in a totally different research environment than existed just a few years ago. The feasibility of simulating complex dynamic nonlinear systems is within the grasp of the present generation of agricultural economists. The development of the DYNAMO simulation language used in this study and presented in some detail in this report provides the necessary tool to take advantage of the computing facilities now available. DYNAMO was developed to simulate industrial systems in which many more of the variables are endogenous to the system than is the case in agriculture. Yet the DYNAMO language is sufficiently flexible that the authors were able to adapt it to handle all of the environmental conditions and decision processes which arose in this study.

Criticisms frequently leveled against the increased use of computers in research are that the researcher becomes isolated from the basic data of the problem, the analysis becomes too mechanical, and the researcher has little chance to use his intuition and judgment. But in programming a system for simulation, the researcher becomes intimately acquainted with the decision-making processes and the basic data of the operation. In a certain sense, he probably will have a better understanding of the total system than the managers themselves. The experience of having to specify the dynamics of the system in mathematical equations forces the researcher to formulate each decision explicitly. One recommendation based upon the experience of this study is that researchers need to learn the simulation language in order to formulate the appropriate programming procedure. The researchers also should present management with the results.

Applications to Farm Management

Simulation is a way of modeling reality. It is a way of building a theory about reality. Because of the availability of simulation languages and digital computers, it is now possible to build models which account for many aspects of reality heretofore beyond our analytical techniques. In cases where uncertainty characterizes the decision-making environment and a large number of time related interrelationships among variables exist, simulation would appear to be a promising tool of analysis.

In farm management research at the firm level, which has been the emphasis of this study, some degree of caution should be raised in recommending simulation

as a general means of analysis. It would be tempting to use simulation for almost any size of problem; but, it should be made clear that unless simulation provides answers to questions which cannot be answered by simpler techniques, it is doubtful that it should be used at the firm level. However, there are a large number of questions at the firm level which existing techniques cannot adequately answer. As was emphasized throughout this report, these involve questions of decision making under uncertainty, expectation formulation, and other dynamic characteristics of farm management.

As soon as problems involving aggregations beyond the firm level are considered, one finds that simulation competes directly with most other analytical techniques. In problems where a large number of variables are involved in nonlinear and dynamic fashion, simulation is probably the only feasible approach. Nonlinearities and dynamics characterize almost any aggregate study in farm management from supply adjustment to regional and interregional development studies. If the complexities of reality are to be studied in depth, then simulation should be a major tool to consider. One should be reminded that the philosophy of simulation is to make improvements in the system which may not necessarily satisfy optimizing criteria. However, the criteria of improvement must be well specified in order that hypothesized improvements can be tested. Criteria which may be satisfied by proposed improvements are: greater stability, shorter lags in response, and less dispersion of an income stream.

APPENDIX A

SPECIAL FEATURES OF DYNAMO

Form of DYNAMO Equations

The time notation used in writing the equations follows from the discussion in the text and Figure 5. Level equatians use the letter K or J, auxiliaries use K or JK, and rates use JK and KL. The exact subscript relation between variables on the left-hand side and right-hand side of an equation are shown in Table A-1. Constants and initial values of variables have no time subscript.

TABLE A-1

Subscript Notation Used in DYNAMO

Variable on left of equation	Subscript on left	Subscript on variable on right if variable is		
		level	aux.	rate
Level	K	J	J	JK
Auxiliary	K	K	K	JK
Rate	KL	K	K	JK

Level Equations

Level equations are the time integrals of the net flow rates, i.e., the summation of the difference between the input and output rates of flow into and out of a level. There are various level equations which can be used in DYNAMO but the following illustrates the basic idea.1/

1L   V.K = V.J + DT (IN.JK-OUT.JK)

Equation 1L is a difference equation which sums the previous value of variable V at J and the difference between IN and OUT. IN is the inflow rate into the level V and OUT is the outflow rate during the time interval JK. Subscripts indicating time are designated in DYNAMO language by the notation given in the above equation.

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1/ The designation 1L is the form number of the equation as used in DYNAMO. Numbers which precede equations in this section are form numbers used by DYNAMO. See Pugh, op. cit., pp. 20-21, 52.

Suppose:

$IN = 20$ units per week

$OUT = 10$ units per week and the initial value of

$V = 100$ and

$DT = .1$ week then

$V.K = 100 + .1\ (20 - 10) = 101.$ Now when in the next time period

V.K becomes V.J, then the new

$V.K = 101 + .1\ (20 - 10) = 102$ and so on.

The dimensions on V are always in number of units or items.

Rate Equations

The rate equations define the rates of flow between levels of the model. There are many algebraic forms which a rate equation can take.

Two possible forms are:

12 $\quad IN.KL = (C)\ (V.K)$

20 $\quad OUT.KL = \dfrac{V.K}{C}$

where IN is an inflow rate and OUT is an outflow during time interval KL, V is a level at K and C is some constant which when divided into V or multiplied by V, provides the rates. The dimensions on rates are always in units per time interval. The important thing to notice is the time subscripts and that all rate equations are independent of one another since they depend only upon variables which have already been calculated. Interaction between rates will occur through time as the feedback from levels influence rates and, subsequently, levels.[1/]

Auxiliary Equations

Auxiliary equations are used when a rate equation is very complex. Since rate equations specify the decisions in a model they frequently involve a large number of variables which would make the rate equation unduly complicated; hence, a chain of auxiliary equations can be formulated to simplify the rate equation. The auxiliaries could be eliminated by a sequence of substitutions. This does

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1/ See the text material on pages 7 and 10 for a discussion of the sequence of calculations.

not mean that auxiliaries can form a set of simultaneous equations; in DYNAMO, a set of simultaneous equations is an incorrect equation formulation and an error statement will be printed when the program is run on the computer.

The following is a chain of two auxiliary equations which are combined to obtain a rate equation:

27 $\quad X.K = \frac{V.K}{A} + U.K$ where V is a level and A a constant,

44 $\quad U.K = \frac{(R.K)\ (S.K)}{B}$ where R and S are levels and B a constant,

48 $\quad IN.KL = \frac{T.K}{(X.K)\ (Y.K)}$ where T and Y are levels.

Now equation 44 can be substituted into 27 and 27 into 48 to obtain:

$$IN.KL = \frac{T.K}{\frac{V.K}{A} + \frac{(R.K)\ (S.K)}{B} + Y.K},$$

which is the rate equation dependent only upon levels and constants.[1/] However, it is a complicated expression and unacceptable to DYNAMO. Therefore, the rate equation would be simplified by using the auxiliaries. Following are some of the special equation forms which are used in the model. Examples are taken from the model on pages 95 to 101.

Step Equation

A step equation is one in which the value of a variable increases in steps at specified intervals of time. The equation for DYNAMO is written:

45 $\quad V = STEP\ (\pm P, Q)$ in which:

V = initial value if $TIME < Q$

$V = P$ if $TIME \geq Q$

An example from the model is:

$DOR.KL = STEP\ (1,1)$

1/ Notice that the rate equation after the substitutions have been made have no form number, which means DYNAMO would not accept such an algebraic expression. Only equation forms acceptable to DYNAMO can be included in an expression. See: Pugh, op. cit., pp. 52-55.

in which the variable DOR is increased by one day each time that TIME equals one. TIME is a variable which the DYNAMO program counts automatically and is the number of DT's for which calculations have been made. In the model DT = one day, hence, TIME counts the days; however, if DT = .1 day then TIME would count to 10 before the step would be made. In this latter case Q = 10.

Clip Equation

The clip equation specifies different values of the dependent variable when certain conditions are satisfied. The equation for DYNAMO is written thus:

51 $V = \text{CLIP}(\pm P, \pm Q, \pm R, \pm S)$ in which:

$V = P$ if $R \geq S$

$V = Q$ if $R < S$.

An example of a rate equation from the model is:

DORO.KL = CLIP (360, 0, DOR.K, 360)

in which the variable DORO is equal to 360 when DOR, the variable given by the step equation above, is equal to 360, or equals 0 when DOR is less than 360.

Switch Equation

The switch equation is similar to the clip equation but the conditions under which the dependent variable changes are more restricted. The equation is written thus:

49 $V = \text{SWITCH}(\pm P, \pm Q, R)$ in which:

$V = P$ if $R = 0$

$V = Q$ if $R \neq 0$.

This was a very useful equation for getting rates to occur at the appropriate times in the model.

An example is:

JCRR.KL = SWITCH (DJCRR.K, JFMCR, DJCRR.K)

in which the rate JCRR equals DJCRR, an auxiliary specified in another equation,

or JFMCR, a constant, when DJCRR another auxiliary equals 0 or not 0. DJCRR was specified by a TABHL equation discussed in the next paragraph.

Table Equation

The table equation provides the means of specifying the relationship between an independent and dependent variable. It can be written in two ways:

59 V = TABLE (NAME, P, ±N1, ±N2, ±N3) or
58 V = TABHL (NAME, P, ±N1, ±N2, ±N3)

where, NAME is the name of the table in which the numbers are specified, P is the independent variable, N1 is the lowest value of the interval of the independent variable, N2 is the highest value and N3 is the length of successive increments of the independent variable when the value of the dependent variable changes. The distinction between TABLE and TABHL is that the independent variable cannot exceed N1 or N2 in TABLE but can in TABHL. Continuing the example above:

DJCRR.K = TABHL (DORTJ,DOR.K, 30,60,15)

in which the independent variable is DOR and the values of DJCRR are taken from a graph in Figure A-1.

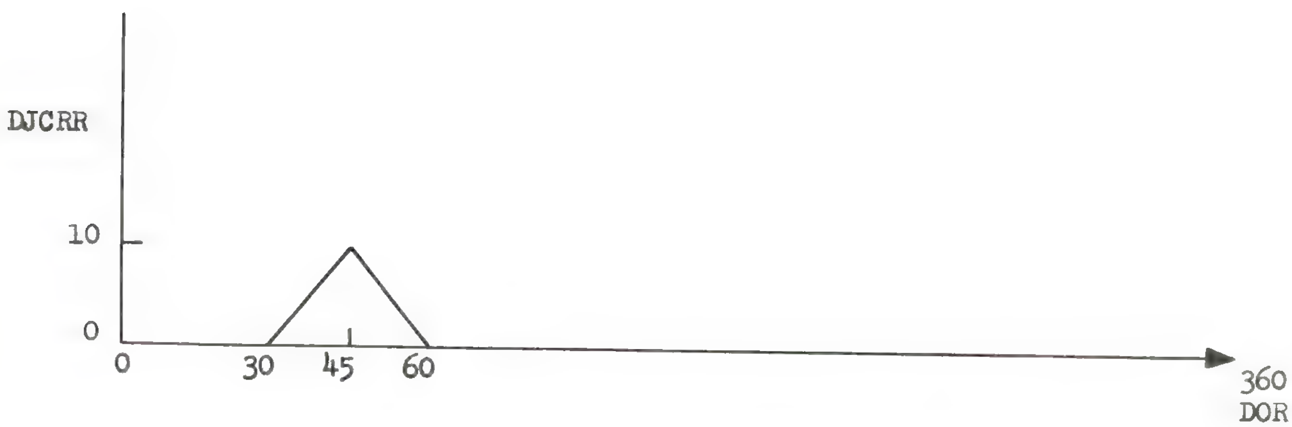

FIGURE A-1. Graph of Relationship between DJCRR and DOR

In the program the values of the dependent variable DJCRR are given in the form:

DORTJ* = 0/10/0 .

Since a TABHL equation is used, whenever DOR is between 0 and 30, or 60 and 360, the value of DJCRR is automatically taken to be 0. If a TABLE equation had been used the value of DJCRR would have to be specified over the entire interval of DOR from 0 to 360. Hence, DORTJ would have to have 25 values instead of only 3. The table equations of DYNAMO automatically interpolate linearly between the values specified in DORTJ. Curved graphs can be specified only by using linear segments; however, the increment in the independent variable N3 can be specified small enough to allow any degree of approximation desired.

Sample Equation

The sample equation will draw a sample from a specified probability distribution at specified time intervals. The equation for DYNAMO is written thus:

43 V = SAMPLE (±P, Q) where

V is set equal to P at sample times separated by intervals of length Q. The variable P takes on the value of a random number given by one of two other equations which specify a uniform or normal distribution. The uniform distribution is given by:

33 P = (R) NOISE and the normal distribution is given by:

34 P = (±R) NORMRN (±M, S).

The equation with form number 33 gives P as random numbers uniformly distributed between $-\frac{R}{2}$ and $+\frac{R}{2}$. In equation 34, P is the product of ±R times random numbers normally distributed (normal deviates) with mean ±M and standard deviation S.

This set of equations was used extensively in the model to simulate various range conditions.

An example is:

RCD.K = SAMPLE (UDRC.K, 360)

UDRC.K = (35) NOISE

RCD is the range condition in December drawn randomly from a uniform distribution of range conditions (UDRC) at intervals of 360 days (DT's). The random numbers are uniformly distributed between -17.5 and 17.5. An example for the normal distribution is:

SNJ.K = SAMPLE (NDRC.K, 360)
NDRC.K = (1) NORMRN (0, 6.25).

SNJ is the sample number for January drawn at random from a normal distribution (NDRC) at intervals of 360 days. The random numbers are normally distributed with a mean of 0 and standard deviation of 6.25.

One feature of the random number generator built into DYNAMO is that in reruns of a model on the computer the same sequence of numbers will be generated. In this way modifications in the model can be made and tested using the same simulated environment. In the event that a different sequence of random numbers is desired this can be effected by inclusion of a NOISE card.1/

Programming for 7090 Computer

DYNAMO will do its intended task only if certain rules are followed in writing the model equations and preparing the cards for processing. While all the details cannot be given here, sufficient information is provided so that the reader will be able to read and understand the next section of this report on the DYNAMO range-feedlot model.

1. Up to and including five uppercase letters can be used to name variables and constants. Letters used to represent variables and constants in the equations should be chosen to display as much mnemonic meaning as possible, e.g., taking the first letter of the words describing the variables will aid in recalling what the variable represents. For example, DOR stands for Days On Range.

2. The variable type and the equation form number must be punched in the first three columns of each card that contains a variable, constant, or equation.

a. The form numbers are given in DYNAMO User's Manual on pages 52-55. (Some examples were shown in the previous subsection.)

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1/ Pugh, *op. cit.*, p. 36.

b. The letters designating the variable types are: L = level, R = rate, A = auxiliary, C = constant, and N = initial value. A NOTE is not processed by DYNAMO but can be used by the programmer to aid in organizing and spacing his program.

3. The exact punching format for the equations must be followed. Examples can be seen in the model on page 95. See the DYNAMO User's Manual for details.

4. Equations may not extend beyond Column 72. Continuation cards must be used if more space is required and are punched with an X n in columns one and two (n = 1, . . . , number of cards required for information). A space must follow the end of the equation or constants. After the final space any comments may be added, e.g., the name of the variable or units of numerical values.

5. Cards can be numbered in Columns 73 through 80.

6. In order to get a model started on the computer, certain variables require an initial value. All levels require an initial value. DYNAMO will provide initial values for auxiliaries and rates as long as no set of simultaneous equations has been included in the model.

7. Direction cards included in the model are:

a. Identification which is the first card in a deck, contains the problem number, programmer's number, DYN, TEST, minutes run is expected to take, maximinutes to allow program to run, and 0,0.

b. RUN which assigns a number to the particular computer run. This number will appear on each page of printed or plotted results.

c. SPEC which specifies DT, LENGTH, PRTPER AND PLTPER. DT is interval of time between J and K; LENGTH is the length of time for which the model is run; PRTPER is the interval of time between printing of the results; PLTPER is the interval of time between plotting of the results. PRTPER and PLTPER are chosen as integral multiples of DT.

d. PRINT which tells the computer the tabular form that is desired for the results. The PRINT card can be seen on page 101. Time is automatically printed in the leftmost column. The variable name and the scale factors are printed automatically. DYNAMO will use its own scale factors or they can be specified on the PRINT card. For further details of setting up the PRINT card see DYNAMO User's Manual.

e. PLOT which tells the computer which variables to plot. The quantities which should bear the same scale can be specified, but the choice of scale can be left to DYNAMO. When PLTPER = 0 no PLOT card is required. Although plots were obtained for some runs of the model, they are too voluminous to include here. They were useful, however, in providing a quick check on the model's performance in initial runs.

8. A deck of cards for a run on the computer consists of an identification card followed by a RUN card and then the model. The order of cards for the model is arbitrary except for continuation cards. They must follow the parent card. DYNAMO does the rest. Reruns of the same model in which given constants are varied can be accomplished by providing another RUN card followed by the new values of the constants. New equations can only be introduced into the model by starting the deck through again.

9. One of the outstanding features of DYNAMO simulation is that there is a precompiling program available on the IBM 1620 computer which will check for most errors which programmers make in writing DYNAMO programs. Those errors which the 1620 doesn't find are first sought out by the DYNAMO program on the 7090 and printed on the online tabulator. The errors must be corrected before proceeding. In this way a minimum of 7090 time is used before the model is actually compiled for generating the results.

APPENDIX B

RANGE-FEEDLOT DYNAMO MODEL

Introduction

This appendix is concerned with the specific equations of the model. Each decision is described under a separate heading wherein the equations are discussed. The entire set of equations are presented on pages 95 to 101. Reference will be made to sets of equations by referring to the card numbers which appear on the far right of each line. (The type of equation indicated by the number at the far left is discussed in Appendix A.)

Decisions on Buying Rates of Feeders for Range

The decision to buy the 300-pound feeders in January, February, and March does not depend upon any other variables in the model except the time of the year.[1/] Hence, the equations on cards number 12 through 20 are concerned with getting the buying rates JCRR, FCRR, and MCRR to occur on the appropriate days.[2/] This is accomplished by using the SWITCH and TABHL functions. The constant rate of buying feeders for the range is 13.79 head per day which will occur for 29 days each month according to the TABHL function.[3/] The variable JFMRR is the total number purchased during the three months and is used to obtain the total number of beef on range (TNBR) on card number 141.

Similar to the previous decision, the buying rate decision in October and November depends only upon the time of the year. A SWITCH and a TABHL function provide the means for the rate of 23.73 head per day to occur for 59 days between 270 and 330 days on range.

The decision concerning the number of 465-pound feeders to buy in December, January, and February depends upon the range conditions existing during each respective month. For December a sample is drawn from a uniform distribution (Table 5) with an interval of 35. The equation on card number 26 draws a sample every 360 days and the equation on card number 27 specifies the appropriate uniform distribution. The function defined on cards number 28 and 29 gives the

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1/ The number of days on range or the number of days in a year are counted by the equations on cards number 9 through 11. There are 360 days in the model's year and 12 months of 30-day duration.

2/ Each variable discussed in this section is usually defined on the card on which it is the dependent variable.

3/ 29 x 13.79 = 400 head. The way the TABHL function operates it is necessary to specify the rate and number of days in this way.

stocking rate per day as a function of range conditions. It is a linear function as shown in Figure B-1.1/

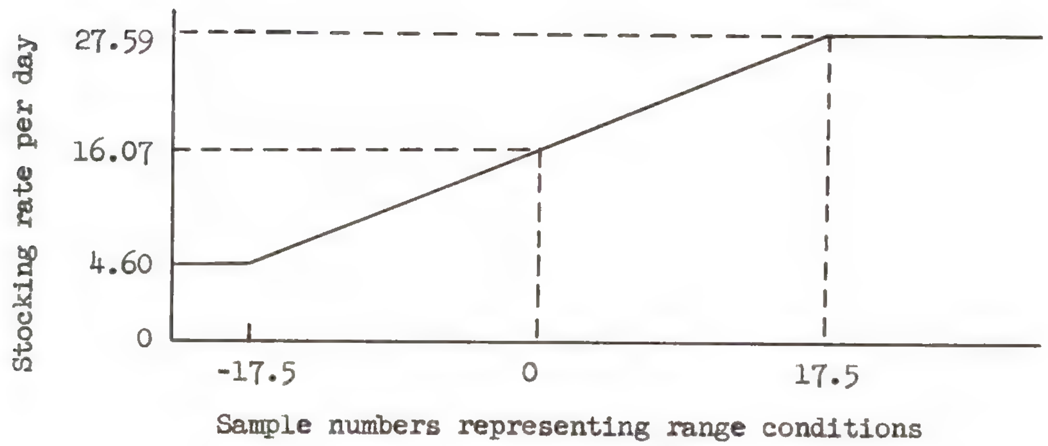

FIGURE B-1. Stocking Rates as a Function of Range Conditions

The SWITCH and TABHL equations on cards number 30 and 31 provide that the rate decision occurs on 29 days between 330 and 360 days on range.2/

1/ This figure is identical to Figure 8 except that the horizontal axis has been transformed for programming purposes, and the vertical axis now represents rates per day rather than the rates per month.

2/ See footnote 3/ on page 85.

The mechanism for making the stocking rate decision in January and February is similar to the December decision except that the sample number is drawn from a normal distribution with a mean of zero and a standard devistion of 6.25 (Table 5) and it is added to the value from the previous month. The stocking rates are taken from a table constructed from Figure B-1. The equations for January and February appear on cards number 33 through 44.

Decisions on Transfer Rates of Feeders from Range to Feedlot

The 300-pound animals which were placed on the range in January, February, and March are ready to be transferred to the feedlot the following February, March, and April at the same rate at which they were placed on the range. The equations which simulate these transfer decisions appear on cards number 48 through 59. The equations for the January rate (cards no. 48-50) are included for flexibility in the event that it is desirable to test for the effects of earlier transfer. Including a rate for each month, JTFLC, FTFLK, MTFLK, ATFLK, also introduces flexibility into the program in the event that tests will be made of different rates of transfer.

The number of 465-pound animals that were placed on the range in October, November, December, January, and February to transfer in March, April, May, and June involve a decision dependent upon range conditions, the number of animals on range and the concept of the flow-stock nature of the range feed supply. The management can adjust the number of animals on the range during any month, say March, by observing the range condition every day if necessary. To simulate this situation, a desired number of animals to have on the range on the first of April was determined (card no. 69). This was established in the model by first drawing a sample number from a uniform distribution with an interval of 20 (Table 5) (card no. 67). Next, this sample number was added to the March first range condition plus a shift of five (see page 21) (card no. 68). The March first range condition was found by drawing a sample number from a uniform distribution with an interval of 20 (cards no. 61, 62), adding this to the February sample number, plus the mean range condition (Table 5) and a shift of five (card no. 63). Finally, the desired number of animals to have on the range (DNRA) (card no. 69) was taken from a table constructed from Table 6.

The usual number of animals (URORM) which would be transferred during the month of March, if this number depended only upon the number of animals on the

range at the first (NRFM) (card no. 73), is given by a TABHL function (card no. 71) constructed from Table 6.[1/]

The difference (card no. 85) between the number of animals on range the first of March (NRFM), the usual number off range during March (URORM), and the desired number on range the first of April (DNRA) is the number of additional animals which can be transferred to the feedlot during March. The fraction of this difference which is actually transferred depends upon the concept of the stock-flow condition of the range feed supply. The actual number transferred during March (ANORM) (card no. 86) is the usual number plus some adjustment constant (RAK) times the difference defined above (card no. 85). When RAK is equal to 1, a flow concept of the range feed supply is implied; when RAK is equal to 0, a stock concept is implied. In this model it was assumed RAK = 0.5 (see page 32). The actual rate of transfer of animals to the feedlot is the actual number divided by the number of days (card no. 89). The TABHL function on card number 91 assures that the rate occurs during the 29 days between 60 and 90 days on range.

A numerical example at this point may aid in understanding how this sequence of equations simulates the decision to transfer animals from the range to the feedlot. Suppose the sample number drawn for March was 8, the number for April was -3, and the range condition in February was 4, then the range condition on the first of April would be:

$$RCA.K = 4 + 8 + 5 + 78 - 3 + 5 = 97$$

The desired number to have on the range the first of April would be 2850 (card no. 70). Suppose that there are 3300 animals on the range the first of March (card no. 73), then the usual number to remove during March is 825 animals (card no. 72). The difference defined on card number 85 is:

$$DNUD.K = 3300 - 825 - 2850 = -375$$

that is, the range is somewhat understocked for the present "good" condition of the range. Hence, the actual number which would be transferred is:

1/ Equations on cards number 75 through 83 are used to balance the accounting equation for NRFM on card number 73.

ANORM.K = 825 + (0.5) (-375) = 638.

The daily rate would be:

AROMM.K = 22 head.

A similar procedure is used to obtain the actual rate of transfer to the feedlot during April (cards no. 93-112) and May (cards no. 114-129). During June the remaining animals are removed (cards no. 130-137). The sequence of level equations on cards number 138 through 140 count the numbers of animals going onto the range and being transferred to the feedlot. The equation on card number 141 adds these numbers.

Decisions on Direct Buying for the Feedlot, May and June

The decision to buy additional 600-pound feeders to fill the feedlot in May and June depends upon the capacity of the lot, the number of animals still to be transferred from the range, and the relationship between the feeder prices and the expected prices of slaughter animals 145 days hence. First, the model simulates this situation by calculating the maximum possible number of animals to buy (MAXNB) (card no. 147). It subtracts from the capacity the total number in the feedlot at present (TNIF), and the total number on the range still to be transferred (TNBR - JFMB). The remaining terms in the equation on card number 147 are accounting terms to keep MAXNB constant during May and June. Second, the model selects a buying rate adjustment factor (card no. 153) from a table constructed from Figure B-2 (cards no. 154-156). Then, the constant is multiplied times the maximum number to buy per day (card no. 151) on card number 160. The May buying rate occurs between 120 and 150 days on range as determined by the SWITCH function on cards number 161 and 162. The same procedure applies to June.

Buying Rate Adjustment Constant

The buying rate adjustment constant when the expected slaughter price is assumed known for certain is shown in Figure B-3.[1/] This corresponds to Price Expectation Model B (page 36). Other runs of the model used Price Expectation

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1/ The three figures presented in this section are based on the general concept illustrated in Figure 9.

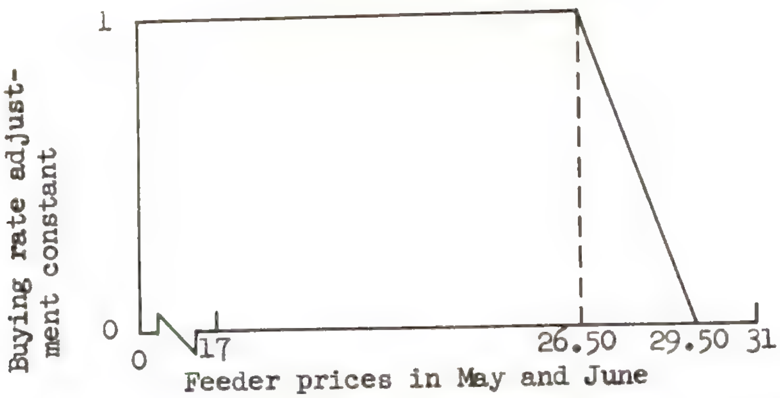

FIGURE B-2. Buying Rate Adjustment Constant as a Function of May and June Feeder Prices when the Previous Year's Slaughter Prices are Expected (Model A)

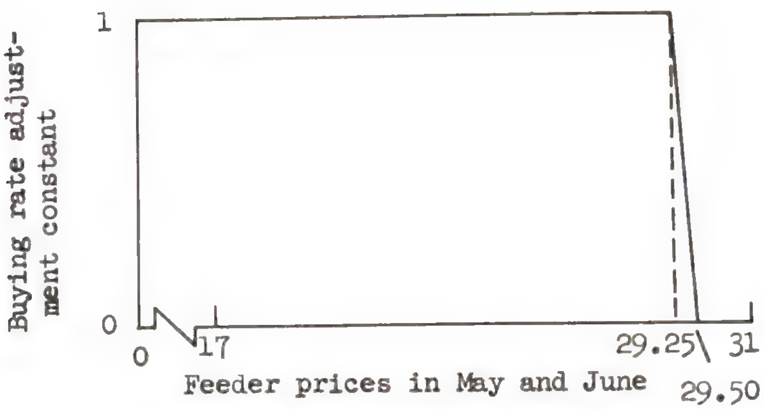

FIGURE B-3. Buying Rate Adjustment Constant as a Function of May and June Feeder Prices when the Slaughter Price is Known with Certainty (Model B)

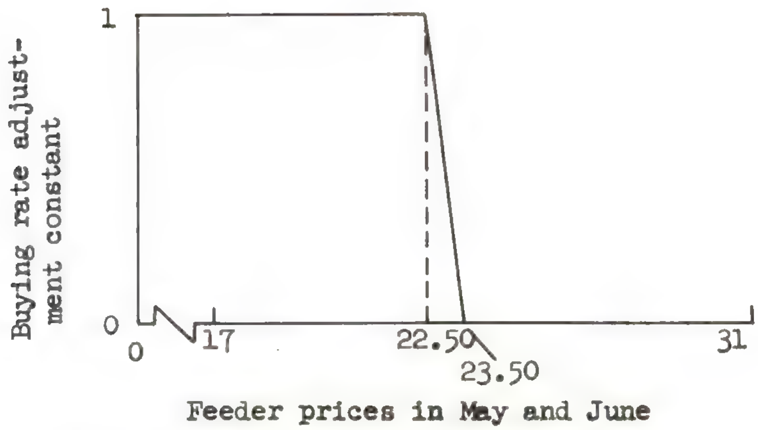

FIGURE B-4. Buying Rate Adjustment Constant as a Function of May and June Feeder Prices when the Expected Slaughter Price is Based on Seasonally Adjusted May and June Prices (Model C)

Models A and C. For example, these two runs are shown at the end of the program where in the first (cards no. 326-338) the previous year's slaughter prices are expected (Model A) and in the second (cards no. 340-351) the seasonally adjusted May and June slaughter prices are expected (Model C). For Model A the buying rate adjustment constant comes from a table (cards no. 336-338) constructed from Figure B-2. For Model C the buying rate adjustment constant comes from a table (cards no. 350-351) constructed from Figure B-4.

In each of the figures the value of the feeder prices at which the buying rate adjustment constant becomes zero is the buying break-even point (page 33). The length of the interval between this break-even price and the price at which the buying rate adjustment constant becomes one indicates the degree of confidence (uncertainty margin) with which the management holds each of the expectation models. Thus, in the case in which management forecasts the slaughter price with greatest confidence the length of the interval is only $0.25 (Figure B-3). However, the case in which least confidence is shown the interval is $3.00 in length (Figure B-2). In the intermediate case the interval is $1.00 in length (Figure B-4).

Decisions on Sales Rates

In this model the decision concerning the time to sell the slaughter animals from the feedlot depends upon the number of days that the animals have been on feed.[1/] The 1200 animals which come into the feedlot in February, March, and April (cards no. 53-59) are sold during the period of 164 to 256 days on feed (card no. 177).

Since the animals which came into the feedlot during March, April, May, and June came in at variable rates, each of these rates are accumulated (cards no. 180, 186, 192, 199) and then divided by 29 (cards no. 181, 187, 194, 201) to give the daily rate of sales. The SWITCH and TABLE functions are used to assure that these rates occur in the appropriate time interval.[2/]

- -

1/ Although the days counter (cards no. 9-11) which was used for days on range could be used again in this part of the program, a new counter, DOF days on feed (cards no. 172-174) was inserted to help the programmer keep the sectors of the model separate.

2/ This variation in the use of TABLE in contrast to TABHL in other sections of the program shows the greater efficiency in card punching for TABHL.

The equation on card number 208 accumulates all of the sales rates; the accumulation of rates of animals coming into the feedlot was calculated on cards number 139 and 140. The total number of animals in the feedlot at the present K time is calculated by the equation on card number 210.

This completes the discussion of the specific decisions which are involved in the model. The remainder of the program contains the accounting equations, initial values, and the input to the model. These are discussed in the next three subsections.

Accounting Sector of Model

Equations on cards number 218 through 227 calculate and accumulate the revenue from sales of animals whenever these sales may occur.[1/] Prices by 15-day intervals are given on cards number 229 through 231. The 1962 prices appear here; any other set could be used in the initial run of the program.

Feeder costs for the animals with an initial weight (I1) of 300 pounds are accumulated by the equation on card number 235. The costs of animals with an initial weight (IW) of 465 pounds are accumulated by cards number 237 through 243. The costs of feeders purchased in May and June at 600 pounds initial weight (I2) are accumulated by cards number 245 through 247. The 1962 prices of the 300- and 465-pound feeders are given as the input to the program on cards number 318 and 319 by 30-day intervals. The 1962 prices for the 600-pound feeders purchased in May and June are given on cards number 155 and 156.

Total feed costs are accumulated by the equation on card number 255. The feed cost rate (card no. 251) is calculated by multiplying the total number of animals in the feedlot at any time (TNIF) times the feed costs per day per head (FCPH). The feed costs per head per day are given by a TABLE function on cards number 252 through 254.

The difference between the total revenue (TR) (card no. 259), and the sum of the total feeder costs (TFDC) (card no. 260) and the accumulated feed costs (AUFC) (card no. 255) is calculated by the equation on card number 261 and is called PRFIT for gross profit.

1/ The ideal form of level equation would be of the form: $V = V + (DT)(X)(Z)(P + Q)$ which is not available in DYNAMO. However, one of the form: $V = V + (DT)\left(\frac{P + Q}{Y}\right)$ is available. Thus, Y was calculated as $\frac{1}{(X)(Z)}$ to obtain the desired result.

Initial Conditions of Model

Three initial conditions that are nonzero for this model are days on range (DOR) (card no. 265), days on feed (DOF) (card no. 280), and number of beef on range (BIN) (card no. 275). The model run was started on the 331st day (December 1) when 2600 animals were on the range. This starting point was selected because at this point the fewest number and simplest possible decisions had been executed for the new range year. Also the feedlot is empty at this time, hence, BOFF1 and BOFF2 could be set equal to zero. Four other nonzero initial conditions are constants, final slaughter weight (FW = 1000 pounds) (card no. 310), initial weight of feeders bought in January, February, and March (I1 = 300 pounds) (card no. 311), initial weight of other feeders bought for the range (IW = 465) (card no. 312) and initial weight of feeders bought for the feedlot (I2 = 600) (card no. 313). The remaining initial conditions are all zero. The initial conditions are presented on cards number 265 through 300 in the order in which the variable appears in a level equation in the model. Initial values on cards number 302 through 309 set the range conditions to zero.

Input to the Model

The 1962 feeder calf prices are specified as the input to the model. This could have been specified as part of the regular program as DYNAMO does not distinguish this input part of the program from the regular part. The form of the input in this model is somewhat different from that suggested by Forrester.[1/] However, placing the exogenous variables apart from the endogenous ones is no doubt a practical expedient for the programmer.

Remaining Cards

The print statement on cards number 320 through 323 specify the quantities to be printed in the tabular form in which they will appear. The SPEC card number 324 tells the computer (1) the interval of time between computations, DT = 1 day, (2) the length of time to run the model, LENGTH = 14430 or 40 years and 30 days, (3) how frequently to tabulate the results, PRTPER = 5 or every 5 days, and (4) how frequently to plot the results, PLTPER = 0 or no plot is desired.

1/ Forrester, op. cit., p. 248.

The RUN card (card no. 325) specifies another run of the model using a different set of feed costs (cards no. 327, 328), slaughter prices (cards no. 329-331), feeder prices in May and June (cards no. 332, 333), other feeder prices (cards no. 334, 335), and the May and June buying rate constant (cards no. 336-338).

TABLE B-1

DYNAMO Equations of Range-Feedlot Model

```
*       HD1-1,DYN,TEST,4,10,0,0
RUN     HD1962
NOTE
NOTE    MODEL OF M-S FEEDLOT
NOTE
NOTE    RANGE SECTOR
NOTE    STOCKING RATES
NOTE
1L      DOR.K=DOR.J+(DT)(DORS.JK-DORO.JK)             DAYS ON RANGE
45R     DORS.KL=STEP(1,1)
51R     DORO.KL=CLIP(360,0,DOR.K,360)
49R     JCRR.KL=SWITCH(DJCRR.K,JFMCR,DJCRR.K)         JAN CONSTANT RANGE RATE
58A     DJCRR.K=TABHL(DORTJ,DOR.K,0,30,15)
C       DORTJ*=0/10/0
49R     FCRR.KL=SWITCH(DFCRR.K,JFMCR,DFCRR.K)         FEB CONSTANT RANGE RATE
58A     DRCRR.K=TABHL(DORTJ,DOR.K,30,60,15)
49R     MCRR.KL=SWITCH(DMCRR.K,JFMCR,DMCRR.K)         MAR CONSTANT RANGE RATE
58A     MCRR.K=TABHL(DORTJ,DOR.K,60,90,15)
C       JFMCR=13.79                                   HEAD PER DAY
52L     JFMRR.K=JFMRR.J+(DT)(JCRR.JK+FCRR.JK+MCRR.JK+0.)
58A     DONRR.K=TABHL(DORT,DOR.K,270,330,15)
C       DORT*=0/10/10/10/0
C       ONRRK=23.73                                   HEAD PER DAY
49R     ONRR.KL=SWITCH(DONRR.K,ONRRK,DONRR.K)         OCT NOV RANGE RATE
NOTE    RANGE CONDITIONS AND RATES
43A     RCD.K=SAMPLE(UDRC.K,360)                      DEC RANGE CONDITION
33A     UDRC.K=(35)NOISE                              UNIFORM DISTRIBUTION
58A     SRD.K=TABHL(SRTB1,RCD.K,-17.5,17.5,17.5)      STOCKING LEVEL DEC
C       SRTB1*=4.60/16.07/27.59
49R     DRR.KL=SWITCH(DDR.K,SRD.K,DDR.K)              DEC RANGE RATE
58A     DDR.K=TABHL(DORTJ,DOR.K,330,360,15)
NOTE
43A     SNJ.K=SAMPLE(NDRC.K,360)                      SAMPLE NO JAN
34A     NDRC.K=(1)NORMRN(0,6.25)                      NORMAL DISTRIBUTION
7A      RCJ.K=RCD.K+SNJ.K                             JAN RANGE CONDITION
58A     SRJ.K=TABHL(SRTB1,RCJ.K,-17.5,17.5,17.5)      STOCKING LEVEL JAN
49R     JRR.KL=SWITCH(DJR.K,SRJ.K,DJR.K)              JAN RANGE RATE
58A     DJR.K=TABHL(DORTJ,DOR.K,0,30,15)
NOTE
43A     SNF.K=SAMPLE(NDRC.K,360)                      SAMPLE NO FEB
7A      RCF.K=RCJ.K+SNF.K                             FEB RANGE CONDITION
58A     SRF.K=TABHL(SRTB1,RCF.K,-17.5,17.5,17.5)      STOCKING LEVEL FEB
49R     FRR.KL=SWITCH(DFR.K,SRF.K,DFR.K)              FEB RANGE RATE
58A     DFR.K=TABHL(DORTJ,DOR.K,30,60,15)
NOTE
NOTE    RANGE TO FEEDLOT RATES
NOTE
```

TABLE B-1 continued.

51R	JTFL.KL=CLIP(0,JTFLC,DOR.K,31)	JAN TO FDLOT CONSTANT RATE
C	JTFLC=0.0	
58A	DFTFL.K=TABHL(TDOR,DOR.K,30,60,15)	
C	TDOR*=0/10/0	
C	FTFLK=13.79	HEAD PER DAY
49R	FTFL.KL=SWITCH(DFTFL.K,FTFLK,DFTFL.K)	FEB TO FDLOT CONSTANT RATE
58A	DMTFL.K=TABHL(TDOR,DOR.K,60,90,15)	
C	MTFLK=13.79	HEAD PER DAY
49R	MTFL.KL=SWITCH(DMTFL.K,MTFLK,DMTFL.K)	MAR TO FDLOT CONSTANT RATE
58A	DATFL.K=TABHL(TDOR,DOR.K,90,120,15)	
C	ATFLK=13.79	HEAD FOR 29 DAYS
49R	ATFL.KL=SWITCH(DATFL.K,ATFLK,DATFL.K)	APR TO FDLOT CONSTANT RATE
NOTE	RANGE CONDITIONS AND FDLOT RATES	
43A	SNM.K=SAMPLE(UDRC2.K,360)	SAMPLE NO MAR
33A	UDRC2.K=(20)NOISE	UNIFORM DISTRIBUTION
9A	RCM.K=RCF.K+SNM.K+FSHFT+MEDRC	MAR RANGE CONDITION
C	FSHFT=5	SHIFT FROM FEB
C	MEDRC=78	MEDIAN RANGE CONDITION
43A	SNA.K=SAMPLE(UDRC3.K,360)	SAMPLE NO APRIL
33A	UDRC3.K=(20)NOISE	UNIFORM DISTRIBUTION
8A	RCA.K=RCM.K+SNA.K+FSHFT	RANGE CONDITION APRIL
58A	DNRA.K=TABHL(DNRAT,RCA.K,61,95,17.5)	DESIRED NO ON RANGE
C	DNRAT*=1350/2100/2850	
58A	URORM.K=TABHL(URRMT,NRFM.K,1800,3800,1000)	USUAL NO OFF RANGE
C	URRMT*=450/700/950	
10A	NRFM.K=TNBR.K-JFMB+AMTFL.K+AMRR.K-AMCRR.K+0.0	NO ON RANGE MARCH
NOTE	EQUATIONS TO BAL NRFM	
49R	MTFLO.KL=SWITCH(P1.K,AMTFL.K,P1.K)	
58A	P1.K=TABHL(R2,DOF.K,358,360,1)	
C	R2*=0/1/0	
49R	MRRO.KL=SWITCH(P1.K,AMRR.K,P1.K)	
49R	MCRRO.KL=SWITCH(P1.K,AMCRR.K,P1.K)	
1L	AMTFL.K=AMTFL.J+(DT)(MTFL.JK-MTFLO.JK)	ACC MAR TO FDLOT K
1L	AMRR.K=AMRR.J+(DT)(MRR.JK-MRRO.JK)	ACC MAR TO FDLOT RR
1L	AMCRR.K=AMCRR.J+(DT)(MCRR.JK-MCRRO.JK)	ACC MAR RANGE RATE
C	JFMB=1200	
NOTE		
8A	DNUD.K=NRFM.K-URORM.K-DNRA.K	DIFF NO USUAL DESIRED
15A	ANORM.K=(URORM.K)(1.)+(RAK)(DNUD.K)	ACTUAL NO OFF MAR
C	RAK=.5	RANGE ADJUST CONSTANT
20A	ARORM.K=ANORM.K/DAYA	ACTUAL RATE OFF MAR
C	DAYA=29	
49R	MRR.KL=SWITCH(DMR.K,ARORM.K,DMR.K)	MAR TO FDLOT RATE
58A	DMR.K=TABHL(DORTJ,DOR.K,60,90,15)	
NOTE		
43A	SNMY.K=SAMPLE(NDRC.K,360)	SAMPLE NO MAY
7A	RCMY.K=RCA.K+SNMY.K	RANGE CONDITION MAY
58A	DNRMY.K=TABHL(DNMYT,RCMY.K,61,95,17.5)	DESIRED NO OFF RANGE
C	DNMYT*=900/1400/1900	
58A	UROA.K=TABHL(URRAT,NRFA.K,1350,2850,750)	USUAL NO OFF RANGE
C	URRAT*=450/700/950	
9A	NRFA.K=TNBR.K-JFMB+AARR.K+AATFL.K	NO ON RANGE APRIL

TABLE B-1 continued.

NOTE	EQUATIONS TO BAL NRFA		100
1L	AARR.K=AARR.J+(DT)(ARR.JK-ARRO.JK)	ACC APRIL TO FDLOT RR	101
1L	AATFL.K=AATFL.J+(DT)(ATFL.JK-ATFLO.JK)	ACC APR TO FDLOTK RATE	102
1L	ACMBR.K=ACMBR.J+(DT)(MYBR.JK-MYBRO.JK)	ACC MAY BUYING RATE	103
49R	ARRO.KL=SWITCH(P1.K,AARR.K,P1.K)		104
49R	ATFLO.KL=SWITCH(P1.K,AATFL.K,P1.K)		105
49R	MYBRO.KL=SWITCH(P1.K,ACMBR.K,P1.K)		106
NOTE			107
8A	DNUD2.K=NRFA.K-UROA.K-DNRMY.K	DIFF NO USUAL DESIRED	108
15A	ANORA.K=(UROA.K)(1)+(RAK)(DNUD2.K)	ACTUAL NO OFF APRIL	109
20A	ARORA.K=ANORA.K/DAYA	ACTUAL RATE OFF APRIL	110
49R	ARR.KL=SWITCH(DAR.K,ARORA.K,DAR.K)	APRIL TO FDLOT RATE	111
58A	DAR.K=TABHL(DORTJ,DOR.K,90,120,15)		112
NOTE			113
43A	SNJU.K=SAMPLE(NDRC.K,360)	SAMPLE NO JUNE	114
7A	RCJU.K=RCMY.K+SNJU.K	RANGE CONDITION JUNE	115
58A	DNRJ.K=TABHL(DNJT,RCJU.K,61,95,17.5)	DESIRED NO OFF RANGE	116
C	DNJT*=350/600/850		117
58A	UROMY.K=TABHL(URMYT,NRFMY.K,900,1900,500)	USUAL NO OFF RANGE	118
C	URMYT*=550/800/1050		119
8A	NRFMY.K=TNBR.K-JFMB+AMYRR.K	NO ON RANGE MAY	120
NOTE	EQUATIONS TO BAL NRFMY		121
1L	AMYRR.K=AMYRR.J+(DT)(MYRR.JK-MYRRO.JK)	ACC MAY TO FDLOT RR	122
49R	MYRRO.KL=SWITCH(P1.K,AMYRR.K,P1.K)		123
NOTE			124
8A	DNUD3.K=NRFMY.K-UROMY.K-DNRJ.K	DIFF NO USUAL DESIRED	125
15A	ANOMY.K=(UROMY.K)(1.)+(RAK)(DNUD3.K)	ACTUAL NO OFF MAY	126
20A	AROMY.K=ANOMY.K/DAYA	ACTUAL RATE OFF MAY	127
49R	MYRR.KL=SWITCH(DMYR.K,AROMY.K,DMYR.K)	MAY TO FDLOT RATE	128
58A	DMYR.K=TABHL(DORTJ,DOR.K,120,150,15)		129
8A	ANOJ.K=TNBR.K-JFMB+AJURR.K		130
NOTE	EQUATIONS TO BAL ANOJ		131
1L	AJURR.K=AJURR.J+(DT)(JURR.JK-JURRO.JK)		132
49R	JURRO.KL=SWITCH(P1.K,AJURR.K,P1.K)		133
NOTE			134
20A	AROJ.K=ANOJ.K/DAYA	ACTUAL RATE OFF JUNE	135
49R	JURR.KL=SWITCH(DJUR.K,AROJ.K,DJUR.K)	JUNE TO FDLOT RATE	136
58A	DJUR.K=TABHL(DORTJ,DOR.K,150,180,15)		137
52L	BIN.K=BIN.J+(DT)(DRR.JK+JRR.JK+FRR.JK+ONRR.JK)		138
2L	BOFF1.K=BOFF1.J+(DT)(JTFL.JK+FTFL.JK+MTFL.JK+ATFL.JK+MRR.JK+0.)		139
52L	BOFF2.K=BOFF2.J+(DT)(MYRR.JK+JURR.JK+ARR.JK+0.)		140
9A	TNBR.K=BIN.K-BOFF1.K-BOFF2.K+JFMRR.K	TOTAL NO BEEF ON RANGE	141
NOTE			142
NOTE	FEEDLOT SECTOR		143
NOTE	MAY AND JUNE BUYING		144
NOTE			145
NOTE		MAX NO TO BUY MAY JUNE	146
11A	MAXNB.K=CAP-TNIF.K-TNBR.K+JFMB-AMJJA.K+ACMBR.K+ACJBR.K+0.		147
1L	AMJJA.K=AMJJA.J+(DT)(MJJAS.JK-JJASO.JK)		148
49R	JJASO.KL=SWITCH(P1.K,AMJJA.K,P1.K)		149
C	CAP=5000		150
20A	MAXBR.K=MAXNB.K/DTMJ		151
C	DTMJ=58	DAYS	152

TABLE B-1 continued.

```
58A     BRKA.K=TABHL(TBRKA,FDPMJ.K,.17,.31,.0025)    BUYING RATE ADJUST CONSTANT
59A     FDPMJ.K=TABLE(FPMJT,DOR.K,1,360,30)
C       FPMJT*=.2458/.2478/.2488/.2494/.2500/.2416/.2350/.2395/.2412/.2412
X1      /.2462/.2506/.2531                           1962 M J FDER PRICE
NOTE    1962 CERTAIN PRICE EXPECTED
C       TBRKA*=1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1
X1      /1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/0/0/0/0/0/0/0
12A     AMYBR.K=(BRKA.K)(MAXBR.K)
49R     MYBR.KL=SWITCH(DMYBR.K,AMYBR.K,DMYBR.K)      MAY BUYING RATE
58A     DMYBR.K=TABHL(DORTJ,DOR.K,120,150,15)
NOTE
12A     AJBR.K=(BRKA.K)(MAXBR.K)
49R     JBR.KL=SWITCH(DJBR.K,AJBR.K,DJBR.K)          JUNE BUYING RATE
1L      ACJBR.K=ACJBR.J+(DT)(JBR.JK-JBRO.JK)         ACC JUNE BUYING RATE
49R     JBRO.KL=SWITCH(P1.K,ACJBR.K,P1.K)
58A     DJBR.K=TABHL(DORTJ,DOR.K,150,180,15)
NOTE
NOTE    SALES RATES
NOTE
45R     DOFS.KL=STEP(1,1)
1L      DOF.K=DOF.J+(DT)(DOFS.JK-DOFO.JK)            DAYS ON FEED
51R     DOFO.KL=CLIP(360,0,DOF.K,360)
NOTE
49R     MJJAS.KL=SWITCH(DJJAS.K,KJJAS,DJJAS.K)       JUNE JULY AUG SEPT SALE
58A     DJJAS.K=TABHL(DORTJ,DOF.K,164,256,46)
C       KJJAS=13.19                                  HEAD FOR 90 DAYS
NOTE
1L      ANM.K=ANM.J+(DT)(MRR.JK-MRRO.JK)             ACC NO FEED LOT MARCH
20A     AJYSR.K=ANM.K/DAYA
49R     JYSR.KL=SWITCH(DJYSR.K,AJYSR.K,DJYSR.K)      JULY SALES RATE
59A     DJYSR.K=TABLE(DOFT1,DOF.K,0,361,15)
C       DOFT1*=0/0/0/0/0/0/0/0/0/0/0/0/10/0/0/0/0/0/0/0/0/0/0
NOTE
1L      ANAU.K=ANAU.J+(DT)(ARR.JK-ARRO.JK)           ACC NO FEEDLOT APRIL
20A     AAUSR.K=ANAU.K/DAYA
49R     AUSR.KL=SWITCH(DAUSR.K,AAUSR.K,DAUSR.K)      AUG SALES RATE
59A     DAUSR.K=TABLE(DOFT2,DOF.K,0,361,15)
C       DOFT2*=0/0/0/0/0/0/0/0/0/0/0/0/0/0/10/0/0/0/0/0/0/0/0
NOTE
52L     ANSP.K=ANSP.J+(DT)(MYRR.JK+MYBR.JK-ANSPO.JK+0.)  NO FEEDLOT MAY
49R     ANSPO.KL=SWITCH(P1.K,ANSP.K,P1.K)
20A     ASPR.K=ANSP.K/DAYA
49R     SPSR.KL=SWITCH(DSPSR.K,ASPR.K,DSPSR.K)       SEPT SALES RATE
59A     DSPSR.K=TABLE(DOFT3,DOF.K,0,361,15)
C       DOFT3*=0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/10/0/0/0/0/0/0
NOTE
52L     ANOC.K=ANOC.J+(DT)(JURR.JK+JBR.JK-ANOCO.JK+0.)  NO FEEDLOT JUNE
49R     ANOCO.KL=SWITCH(P1.K,ANOC.K,P1.K)
20A     AOCR.K=ANOC.K/DAYA
49R     OCSR.KL=SWITCH(DOCSR.K,AOCR.K,DOCSR.K)       OCT SALES RATE
59A     DOCSR.K=TABLE(DOFT4,DOF.K,0,361,15)
C       DOFT4*=0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/10/0/0/0/0
NOTE
```

TABLE B-1 continued.

```
NOTE    LEVEL IN FEEDLOT
NOTE
2L      BSLL.K=BSLL.J+(DT)(MJJAS.JK+JYSR.JK+AUSR.JK+SPSR.JK+OCSR.JK+0.)
NOTE                                            TOTAL NO IN FDLOT
10A     TNIF.K=BOFF1.K+BOFF2.K+AMBR2.K+AJBR2.K-BSLL.K+0.0
1L      AMBR2.K=AMBR2.J+(DT)(MYBR.JK+0.)
1L      AJBR2.K=AJBR2.J+(DT)(JBR.JK+0.)
NOTE
NOTE    ACCOUNTING SECTOR
NOTE
NOTE    REVENUE
NOTE
3L      MJJAA.K=MJJAA.J+(DT)(1/MJJAH.J)(MJJAS.JK+0.0)  MAY J J ACC REV
42A     MJJAH.K=1/((FW)(BPR.K))
3L      JYACR.K=JYACR.J+(DT)(1/JYRH.J)(JYSR.JK+0.0)  JULY ACC REV
42A     JYRH.K=1/((FW)(BPR.K))
3L      AUACR.K=AUACR.J+(DT)(1/AURH.J)(AUSR.JK+0.0)  AUG ACC REV
42A     AURH.K=1/((FW)(BPR.K))
3L      SPACR.K=SPACR.J+(DT)(1/SPRH.J)(SPSR.JK+0.0)  SEPT ACC REV
42A     SPRH.K=1/((FW)(BPR.K))
3L      OCACR.K=OCACR.J+(DT)(1/OCRH.J)(OCSR.JK+0.0)  OCT ACC REV
42A     OCRH.K=1/((FW)(BPR.K))
59A     BPR.K=TABLE(BPRT,DOF.K,1,360,15)             FAT BEEF PRICE
C       BPRT*=.2572/.2572/.2562/.2562/.2638/.2638/.2656/.2656/.2656/.2656/
X1      .2602/.2602/.2569/.2569/.2602/.2602/.2609/.2609/.2599/.2599/.2610/
X2      .2610/.2692/.2692/.2690                      1962 FAT BEEF PRICE
NOTE
NOTE    FEEDER COSTS
42A     JFMCH.K=1/((I1)(FDPR.K))
4L      JFMAC.K=JFMAC.J+(DT)(1/JFMCH.J)(JCRR.JK+FCRR.JK+MCRR.JK+0.+0.+0.)
42A     ONCH.K=1/((IW)(FDPR.K))
3L      ONAC.K=ONAC.J+(DT)(1/ONCH.J)(ONRR.JK+0.0)    OCT NOV ACC COST
42A     DCH.K=1/((IW)(FDPR.K))
3L      DAC.K=DAC.J+(DT)(1/DCH.J)(DRR.JK+0.0)        DEC ACC COST
42A     JCH.K=1/((IW)(FDPR.K))
3L      JAC.K=JAC.J+(DT)(1/JCH.J)(JRR.JK+0.0)        JAN ACC COST
42A     FBCH.K=1/((IW)(FDPR.K))
3L      FBAC.K=FBAC.J+(DT)(1/FBCH.J)(FRR.JK+0.0)     FEB ACC COST
42A     MYCH.K=1/((I2)(FDPMJ.K))
3L      MYAC.K=MYAC.J+(DT)(1/MYCH.J)(MYBR.JK+0.0)    MAY ACC COST
42A     JUCH.K=1/((I2)(FDPMJ.K))
3L      JUAC.K=JUAC.J+(DT)(1/JUCH.J)(JBR.JK+0.0)     JUNE ACC COST
NOTE
NOTE    TOTAL FEED COST
NOTE
12R     VFC.KL=(TNIF.K)(FCPH.K)                      FEED COST RATE
59A     FCPH.K=TABLE(FCT,DOF.K,1,360,30)
C       FCT*=.597/.597/.597/.581/.581/.570/.586/.581/.581/.592/.597/.613/.
X1      624                                          1962 FEED COST
1L      AVFC.K=AVFC.J+(DT)(VFC.JK+0.0)               ACC FEED COST
NOTE
NOTE    PROFIT
NOTE
```

TABLE B-1 continued.

```
10A     TR.K=MJJAA.K+JYACR.K+AUACR.K+SPACR.K+OCACR.K+0.0
11A     TFDC.K=JFMAC.K+ONAC.K+DAC.K+JAC.K+FBAC.K+MYAC.K+JUAC.K
8A      PRFIT.K=TR.K-TFDC.K-AVFC.K
NOTE
NOTE    INITIAL CONDITIONS
NOTE
6N      DOR=331
6N      JFMRR=0
6N      AMTFL=0
6N      AMRR=0
6N      AMCRR=0
6N      AARR=0
6N      AATFL=0
6N      ACMBR=0
6N      AMYRR=0
6N      AJURR=0
6N      BIN=2600
6N      BOFF1=0
6N      BOFF2=0
6N      AMJJA=0
6N      ACJBR=0
6N      DOF=331
6N      ANM=0
6N      ANAU=0
6N      ANSP=0
6N      ANOC=0
6N      BSLL=0
6N      AMBR2=0
6N      AJBR2=0
6N      MJJAA=0
6N      JYACR=0
6N      AUACR=0
6N      SPACR=0
6N      OCACR=0
6N      JFMAC=0
6N      ONAC=0
6N      DAC=0
6N      JAC=0
6N      FBAC=0
6N      MYAC=0
6N      JUAC=0
6N      AVFC=0
NOTE
6N      RCD=0
6N      DRR=0
6N      RCJ=0
6N      RCF=0
6N      RCM=0
6N      RCA=0
6N      RCMY=0
6N      RCJU=0
6N      FW=1000
```

TABLE B-1 continued.

```
6N      I1=300
6N      IW=465
6N      I2=600
NOTE
NOTE    INPUT
NOTE
59A     FDPR.K=TABLE(FDPRT,DOR.K,1,360,30)
C       FDPRT*=.2728/.2731/.2750/.2800/.2825/.2656/.2538/.2625/.2675/.2685
X1      /.2762/.2806/.2850                                  1962 FDER CALF PRICE
PRINT   1)DOR/2)TNBR,TNIF/3)TR,TFDC,AVFC,PRFIT/4)*,RCD,RCJ,RCF/5)ONRR,DRR,
X1      JRR,FRR/6)*,*,*,FTFL/7)*,*,JCRR,FCRR/8)RCM,RCA,RCMY,RCJU/9)MRR,ARR
X2      ,MYRR,JURR/10)MTFL,ATFL/11)MCRR/12)*,*,MYBR,JBR/13)MAXNB,BRKA,ACMB
X3      R,ACJBR/14)MJJAS,JYSR,AUSR,SPSR,OCSR
SPEC    DT=1/LENGTH=14430/PRTPER=5/PLTPER=0
RUN     HD1963
NOTE    1963 LAST YR EXPECTED PRICE
C       FCT*=.624/.624/.629/.608/.592/.565/.581/.613/.613/.619/.646/.646/.
X1      650                                                 1963 FEED COST
C       BPRT*=.2690/.2690/.2515/.2515/.2374/.2374/.2428/.2428/.2314/.2314/
X1      .2348/.2348/.2570/.2570/.2516/.2516/.2398/.2398/.2298/.2298/.2202/
X2      .2202/.2182/.2182/.2242                             1963 FAT BEEF PRICE
C       FPMJT*=.2531/.2482/.2450/.2438/.2422/.2367/.2422/.2348/.2300/.2228
X1      /.2198/.2212/.2216                                  1963 M J FDER PRICE
C       FDPRT*=.2850/.2775/.2750/.2750/.2710/.2612/.2680/.2525/.2588/.2528
X1      /.2564/.2541/.2547                                  1963 FDER CALF PRICE
C       TBRKA*=1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1
X1      /1/1/1/1/1/1/1/1/1/1/.913/.830/.747/.664/.581/.498/.415/.332/.249/.1
X2      66/.083/0/0/0/0/0/0/0
RUN     HD1963
NOTE    1963 SEASONAL PRICE EXPECTED
C       FCT*=.624/.624/.629/.608/.592/.565/.581/.613/.613/.619/.646/.646/.
X1      650                                                 1963 FEED COST
C       BPRT*=.2690/.2690/.2515/.2515/.2374/.2374/.2428/.2428/.2314/.2314/
X1      .2348/.2348/.2570/.2570/.2516/.2516/.2398/.2398/.2298/.2298/.2202/
X2      .2202/.2182/.2182/.2242                             1963 FAT BEEF PRICE
C       FPMJT*=.2531/.2482/.2450/.2438/.2422/.2367/.2422/.2348/.2300/.2228
X1      /.2198/.2212/.2216                                  1963 M J FDER PRICE
C       FDPRT*=.2850/.2775/.2750/.2750/.2710/.2612/.2680/.2525/.2588/.2528
X1      /.2564/.2541/.2547                                  1963 FDER CALF PRICE
C       TBRKA*=1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/.75/.50/.25/0
X1      /0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0/0
```

APPENDIX C

BASIC DATA AND SIMULATION RESULTS

TABLE C-1

Monthly Range Condition Report (as of the first of the month)
District 5 - Sacramento Valley, California

Year	Month: Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1922	75	66	57	74	73	82	85	88	74	78	87	89
1923	96	99	94	65	98	98	90	90	91	86	83	61
1924	57	46	73	59	42	47	53	51	55	51	75	93
1925	84	71	94	105	108	95	98	103	94	93	88	80
1926	82	71	95	90	97	93	95	93	94	85	90	95
1927	95	95	96	102	100	96	90	87	86	84	81	89
1928	88	86	87	100	98	95	90	90	90	88	85	85
1929	80	80	74	76	66	63	67	71	73	71	66	44
1930	64	72	84	92	89	90	85	85	84	83	85	76
1931	55	62	77	76	50	52	56	53	52	51	51	49
1932	63	63	54	76	73	77	78	78	77	76	72	61
1933	55	55	50	63	68	63	63	67	62	62	59	59
1934	71	86	94	97	88	83	77	70	65	63	61	82
1935	94	90	96	96	102	99	94	92	89	87	86	81
1936	71	85	87	86	88	87	86	82	79	73	68	62
1937	45	23	32	58	70	68	70	73	71	71	80	92
1938	93	95	96	98	99	95	90	86	84	85	84	70
1939	74	67	53	58	54	56	54	56	58	56	57	45
1940	44	62	72	88	96	94	86	86	82	84	82	86
1941	86	84	88	92	92	97	88	87	86	82	79	72
1942	92	84	84	80	91	92	87	87	86	81	80	77
1943	81	75	81	90	90	84	84	83	82	82	76	66
1944	63	64	64	61	60	68	70	73	73	73	72	82
1945	91	86	84	87	81	79	79	78	80	80	77	88
1946	84	81	71	73	79	77	76	80	79	78	74	56
1947	71	56	72	84	86	79	72	72	72	68	80	88
1948	80	65	54	66	86	91	88	84	82	80	77	70
1949	65	44	47	74	68	67	69	73	72	70	62	66
1950	61	63	74	82	83	81	81	80	81	76	75	94
1951	92	88	89	84	79	85	81	84	83	81	79	82
1952	81	78	81	72	85	87	85	84	84	81	79	70
1953	76	81	67	70	73	82	85	82	80	76	74	76
1954	71	72	76	86	93	91	85	81	83	76	74	76
1955	73	69	66	61	70	78	79	78	79	72	70	73
1956	74	74	74	71	79	87	83	82	81	76	78	70
1957	66	60	73	81	85	88	82	79	80	82	92	85
1958	87	86	89	88	88	88	85	85	82	83	82	68
1959	63	74	79	70	72	68	72	59	68	74	67	62
1960	59	61	68	77	79	81	79	73	69	73	66	78
1961	81	80	81	83	80	83	78	73	74	77	73	66
1962	73	67	78	81	77	78	77	76	76	76	86	89
1963	90	68	85	87	90	92	87	86	84	81	89	91
1964	86	82	75	72								

Source: Crop and Livestock Reporting Service, U.S. Department of Agriculture, Sacramento, California.

TABLE C-2

Cattle Prices Used in Simulation[a]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	Steer calves, 300-500 lbs., good and choice, Stockton												Jan.-Feb.-Mar., Oct.-Nov.-Dec.
1954	20.19	21.50	21.40	21.00	21.25	20.80	19.50	19.48	19.46	19.24	19.12	19.85	20.22
1955	20.70	20.94	20.98	20.31	20.44	19.65	19.69	18.62	18.00	17.88	17.95	18.82	19.54
1956	19.21	18.90	19.00	19.05	18.76	18.25	18.25	18.35	18.36	17.88	18.20	18.14	18.56
1957	17.81	18.95	21.33	20.90	20.56	20.38	20.30	20.50	21.00	21.45	22.48	24.65	21.11
1958	25.65	26.58	29.75	29.30	28.50	28.50	28.75	27.42	28.83	30.15	29.86	30.65	28.77
1959	31.81	32.50	32.52	32.15	30.78	30.88	31.05	30.00	30.20	29.24	27.22	26.80	30.02
1960	27.69	28.25	28.50	28.25	29.06	26.50	25.62	23.15	24.12	24.92	25.78	26.95	27.02
1961	27.12	27.69	27.50	27.25	25.14	24.84	25.31	25.85	26.00	25.93	26.25	26.75	26.87
1962	27.28	27.31	27.50	28.00	28.25	26.56	25.38	26.25	26.75	26.85	27.62	28.06	27.44
1963	28.50	27.75	27.50	27.50	27.10	26.12	26.80	25.25	25.88	25.28	25.64	25.41	26.68
Year	Feeder steers, 500-800 lbs., 50% good, 50% choice, Stockton												May-June
1954	19.10	20.12	20.10	20.60	21.25	20.62	19.94	19.33	19.28	19.21	18.96	19.78	20.94
1955	20.56	20.85	20.94	20.57	20.38	19.84	19.88	18.83	18.00	17.94	17.78	17.68	20.11
1956	18.12	18.12	18.40	18.42	18.14	17.90	18.00	18.21	18.13	17.40	17.41	17.41	18.02
1957	17.44	18.19	20.06	20.38	20.78	20.07	20.18	20.44	20.16	20.60	22.03	23.08	20.42
1958	23.90	24.82	26.13	26.08	26.62	26.38	26.00	24.91	25.84	26.22	26.18	26.98	26.50
1959	28.59	29.04	29.12	28.96	28.28	27.84	27.88	27.30	27.62	26.40	24.98	24.12	28.06
1960	24.50	24.88	25.60	26.03	25.62	24.62	24.62	24.12	23.14	22.88	23.12	23.81	25.12
1961	24.22	24.34	24.38	24.13	22.66	22.47	22.64	23.11	23.00	22.90	23.26	24.32	22.56
1962	24.58	24.78	24.88	24.94	25.00	24.16	23.50	23.95	24.12	24.12	24.62	25.06	24.58
1963	25.31	24.82	24.50	24.38	24.22	23.67	24.22	23.48	23.00	22.28	21.98	22.12	23.94
Year	Slaughter steers, 900-1,100 lbs., 25% good, 75% choice, Stockton												May-Sept.
1954	23.65	23.36	23.19	23.28	23.98	23.48	23.44	23.44	23.43	23.26	22.88	23.08	23.55
1955	23.36	23.50	23.28	23.31	23.12	22.78	22.74	22.28	21.64	21.12	19.91	19.24	22.51
1956	18.89	18.10	19.11	20.03	19.82	20.26	21.47	22.16	22.34	22.02	20.06	20.03	21.21
1957	19.78	19.76	21.66	22.53	23.21	22.91	23.98	23.68	23.02	21.57	22.10	23.89	23.00
1958	25.21	25.64	27.38	27.66	27.56	27.70	27.49	25.19	25.50	25.62	25.67	26.49	26.69
1959	27.28	27.13	27.28	28.14	28.77	28.78	27.50	26.94	(26.32)[b]	(25.84)[b]	(25.31)[b]	25.59	27.66
1960	26.06	25.88	26.48	27.06	27.22	26.99	25.77	25.29	24.27	23.15	23.11	24.50	25.91
1961	25.08	24.43	24.48	24.23	23.18	23.08	23.44	23.98	24.20	23.86	23.72	24.70	23.58
1962	25.72	25.62	26.38	26.56	26.56	26.02	25.69	26.02	26.09	25.99	26.10	26.92	26.89
1963	26.90	25.15	23.74	24.28	23.14	23.48	25.70	25.16	23.98	22.98	22.02	21.82	24.29

a/ Livestock and Meat Prices and Receipts, 1961; 1962; and 1963, and Livestock and Meat Statistics, 1951-60, California Federal-State Market News Service, Sacramento.

b/ Based only on good grade prices adjusted to 75 percent choice, 25 percent good.

TABLE C-3

Feed Cost per Head per Day, Used in Simulation[a]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual average
1954	.710	.667	.656	.592	.559	.559	.581	.592	.624	.635	.640	.646	.622
1955	.640	.635	.640	.646	.646	.527	.565	.565	.565	.570	.570	.570	.595
1956	.570	.549	.565	.592	.581	.576	.586	.592	.592	.613	.629	.640	.590
1957	.672	.662	.667	.581	.554	.511	.516	.522	.516	.522	.533	.543	.567
1958	.538	.527	.527	.533	.522	.527	.554	.570	.565	.581	.608	.613	.555
1959	.613	.613	.613	.619	.554	.533	.543	.543	.549	.570	.586	.592	.577
1960	.597	.570	.559	.543	.527	.511	.516	.527	.538	.570	.576	.565	.550
1961	.559	.570	.570	.570	.554	.543	.570	.581	.586	.597	.597	.597	.575
1962	.597	.597	.597	.581	.581	.570	.586	.581	.581	.592	.597	.613	.589
1963	.624	.624	.629	.608	.592	.565	.581	.613	.613	.619	.646	.646	.613

a/ Based on calculated ration cost in 1963, then adjusted on the basis of index of monthly barley prices over past ten years.

TABLE C-4

Summary of Simulation Results: 1954 Prices, Models A, B, C

Year	Total revenue: Sales: Cattle	Barley	Manure	Variable costs: Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Bought May & June	Placed in lot
	thousand dollars									index	head		
1	1,165	30	5	481	427	24	36	193	38	83	3,998	1,002	5,000
2	1,168	33	5	438	426	24	38	193	86	97	4,816	184	5,000
3	1,166	32	5	425	426	24	38	193	97	91	4,530	470	5,000
4	1,167	26	5	439	426	24	36	193	80	71	3,830	1,170	5,000
5	1,166	24	5	507	429	24	34	193	8	57	3,020	1,980	5,000
6	1,165	28	5	507	429	24	35	193	10	77	3,514	1,486	5,000
7	1,167	32	5	439	426	24	37	193	84	91	4,426	574	5,000
8	1,167	29	5	452	426	24	38	193	67	81	4,028	972	5,000
9	1,167	28	5	479	426	24	36	193	42	78	4,024	976	5,000
10	1,168	26	5	445	425	24	36	193	75	68	3,910	1,090	5,000
11	1,168	33	5	429	425	24	38	193	95	97	4,682	318	5,000
12	1,166	27	5	483	429	24	35	193	36	74	3,406	1,594	5,000
13	1,167	29	5	484	427	24	36	193	36	81	3,904	1,096	5,000
14	1,168	33	5	448	425	24	38	193	77	93	4,658	342	5,000
15	1,169	30	5	452	425	24	37	193	72	86	4,302	698	5,000
16	1,168	33	5	426	425	24	38	193	101	95	4,632	368	5,000
17	1,168	27	5	460	425	24	36	193	62	72	3,716	1,284	5,000
18	1,167	27	5	476	427	24	35	193	44	76	3,614	1,386	5,000
19	1,167	28	5	467	427	24	36	193	54	79	3,720	1,280	5,000
20	1,168	26	5	488	426	24	35	193	32	70	3,518	1,482	5,000
21	1,168	27	5	498	425	24	35	193	23	72	3,594	1,406	5,000
22	1,170	33	5	390	424	24	38	193	138	100	4,820	180	5,000
23	1,167	25	5	493	427	24	34	193	16	67	3,158	1,842	5,000
24	1,169	28	5	483	425	24	36	193	50	76	3,724	1,276	5,000
25	1,168	29	5	497	426	24	36	193	26	84	3,854	1,146	5,000
26	1,170	33	5	438	424	24	38	193	91	98	4,908	92	5,000
27	1,171	33	5	394	423	24	38	193	134	97	4,804	196	5,000
28	1,167	27	5	481	429	24	34	193	39	72	3,100	1,900	5,000
29	1,168	24	5	527	426	24	34	193	- 7	54	3,010	1,990	5,000
30	1,170	27	5	460	424	24	36	193	63	73	3,904	1,096	5,000
31	1,170	29	5	437	424	24	36	193	38	80	3,944	1,056	5,000
32	1,168	26	5	491	427	24	34	193	30	71	3,226	1,774	5,000
33	1,169	27	5	493	426	24	35	193	29	73	3,420	1,580	5,000
34	1,169	32	5	489	424	24	37	193	39	93	4,286	714	5,000
35	1,172	33	5	420	423	24	38	193	111	96	4,760	240	5,000
36	1,170	28	5	478	424	24	36	193	48	76	3,956	1,044	5,000
37	1,172	33	5	432	423	24	38	193	99	99	4,890	110	5,000
38	1,172	33	5	397	424	24	38	193	133	97	4,764	236	5,000
39	1,169	31	5	469	424	24	36	193	58	90	3,860	1,140	5,000
40	1,169	25	5	515	425	24	34	193	7	65	3,012	1,988	5,000

TABLE C-5

Summary of Simulation Results: 1955 Prices, Models A, B, C

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,078	31	5	462	418	24	35	193	-19	83	3,998	1,002	5,000
2	1,093	34	5	423	420	24	37	193	28	97	4,816	184	5,000
3	1,082	33	5	411	419	24	37	193	37	91	4,530	470	5,000
4	1,084	28	5	423	419	24	35	193	22	71	3,830	1,170	5,000
5	1,076	25	5	488	417	24	33	193	-49	57	3,020	1,980	5,000
6	1,073	29	5	488	417	24	34	193	-48	77	3,514	1,486	5,000
7	1,081	33	5	423	418	24	36	193	25	91	4,426	574	5,000
8	1,081	30	5	436	418	24	37	193	9	81	4,028	972	5,000
9	1,083	30	5	462	418	24	35	193	-15	78	4,024	976	5,000
10	1,085	27	5	428	420	24	35	193	18	68	3,910	1,090	5,000
11	1,085	34	5	415	418	24	37	193	36	97	4,682	318	5,000
12	1,073	28	5	465	416	24	34	193	-25	74	3,406	1,594	5,000
13	1,078	30	5	466	417	24	35	193	-22	81	3,904	1,096	5,000
14	1,086	34	5	433	419	24	37	193	19	93	4,658	342	5,000
15	1,083	32	5	431	418	24	37	193	13	86	4,302	698	5,000
16	1,086	34	5	412	418	24	37	193	41	95	4,632	368	5,000
17	1,081	28	5	443	417	24	35	193	2	72	3,716	1,284	5,000
18	1,077	29	5	459	417	24	34	193	-15	76	3,614	1,386	5,000
19	1,078	30	5	451	416	24	35	193	- 6	79	3,720	1,280	5,000
20	1,080	27	5	470	417	24	34	193	-26	70	3,518	1,482	5,000
21	1,080	28	5	479	417	24	34	193	-34	72	3,594	1,406	5,000
22	1,088	34	5	377	418	24	37	193	77	100	4,820	180	5,000
23	1,076	26	5	481	415	24	33	193	-38	67	3,158	1,842	5,000
24	1,081	29	5	460	417	24	35	193	-13	76	3,724	1,276	5,000
25	1,078	31	5	478	416	24	35	193	-32	84	3,854	1,146	5,000
26	1,089	34	5	423	418	24	38	193	34	98	4,908	92	5,000
27	1,089	34	5	381	418	24	37	193	73	92	4,804	196	5,000
28	1,071	28	5	464	413	24	33	193	-23	72	3,100	1,900	5,000
29	1,078	25	5	507	415	24	33	193	-63	54	3,010	1,990	5,000
30	1,086	28	5	443	417	24	35	193	6	73	3,904	1,096	5,000
31	1,083	30	5	422	416	24	35	193	28	80	3,944	1,056	5,000
32	1,076	28	5	473	415	24	33	193	-30	71	3,226	1,774	5,000
33	1,077	28	5	475	415	24	34	193	-30	73	3,420	1,580	5,000
34	1,082	34	5	471	416	24	36	193	-19	93	4,286	714	5,000
35	1,089	34	5	405	417	24	37	193	51	96	4,760	240	5,000
36	1,086	29	5	460	417	24	35	193	- 8	76	3,956	1,044	5,000
37	1,090	34	5	417	417	24	37	193	41	99	4,890	110	5,000
38	1,089	34	5	385	417	24	37	193	73	97	4,764	236	5,000
39	1,078	33	5	453	414	24	35	193	- 4	90	3,960	1,140	5,000
40	1,077	26	5	515	414	24	33	193	-70	65	3,012	1,988	5,000

TABLE C-6

Summary of Simulation Results: 1956 Prices, Model A

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,068	31	5	424	420	24	33	193	10	83	3,998	921	4,919
2	1,086	34	5	396	424	24	35	193	54	92	4,817	168	4,985
3	1,179	33	5	381	422	24	34	193	62	91	4,530	431	4,961
4	1,168	27	5	385	418	24	32	193	49	71	3,830	1,074	4,904
5	1,050	25	5	416	412	23	30	193	-20	92	3,020	1,817	4,837
6	1,057	29	5	441	415	23	31	193	-15	77	3,515	1,363	4,878
7	1,077	33	5	392	422	24	34	193	61	91	4,427	526	4,953
8	1,071	30	5	400	419	24	34	193	38	81	4,029	891	4,920
9	1,071	29	5	423	418	24	33	193	14	78	4,094	896	4,920
10	1,072	27	5	391	418	24	32	193	45	68	3,909	1,001	4,910
11	1,084	34	5	387	423	24	34	193	63	97	4,702	292	4,974
12	1,056	28	5	419	415	23	31	193	8	74	3,406	1,463	4,869
13	1,066	30	5	425	418	23	32	193	8	81	3,903	1,007	4,910
14	1,084	33	5	403	422	24	34	193	45	93	4,657	315	4,972
15	1,077	31	5	402	420	24	33	193	42	86	4,303	640	4,943
16	1,084	34	5	383	422	24	34	193	66	95	4,633	337	4,970
17	1,065	28	5	402	417	23	32	193	32	72	3,716	1,178	4,894
18	1,061	29	5	415	416	23	32	193	15	76	3,613	1,273	4,886
19	1,063	30	5	409	415	23	32	193	32	79	3,721	1,174	4,895
20	1,061	27	5	425	415	23	31	193	5	70	3,517	1,361	4,878
21	1,064	28	5	435	415	23	32	193	- 1	72	3,593	1,291	4,884
22	1,088	34	5	353	423	24	35	193	100	100	4,820	165	4,985
23	1,053	26	5	430	412	23	30	193	- 5	67	3,157	1,691	4,848
24	1,065	29	5	418	426	23	32	193	16	76	3,724	1,171	4,895
25	1,067	31	5	437	417	23	32	193	- 1	84	3,852	1,052	4,904
26	1,091	34	5	396	422	24	35	193	59	98	4,908	84	4,992
27	1,089	34	5	357	423	24	35	193	97	97	4,804	180	4,984
28	1,050	28	5	414	411	23	30	193	10	72	3,100	1,744	4,844
29	1,052	25	5	453	420	23	30	193	-28	54	3,010	1,826	4,836
30	1,073	28	5	305	417	23	32	193	36	73	3,904	1,006	4,910
31	1,071	30	5	385	416	24	32	193	56	80	3,943	970	4,913
32	1,054	27	5	424	412	23	31	193	3	71	3,227	1,627	4,854
33	1,059	28	5	428	413	23	31	193	3	73	3,420	1,450	4,870
34	1,077	33	5	435	419	24	33	193	12	93	4,286	655	4,941
35	1,089	34	5	379	421	24	34	193	75	96	4,760	220	4,980
36	1,073	29	5	421	416	24	32	193	21	76	3,955	959	4,914
37	1,092	33	5	391	422	24	35	193	65	99	4,891	100	4,991
38	1,089	33	5	359	422	24	34	193	96	97	4,765	216	4,981
39	1,068	33	5	412	416	24	32	193	28	90	3,860	1,046	4,906
40	1,052	26	5	461	409	23	30	193	-34	65	3,011	1,825	4,836

TABLE C-7

Summary of Simulation Results: 1956 Prices, Model B

	Total revenue			Variable costs							Total number of cattle		
	Sales												
Year	Cattle	Barley	Manure	Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Placed on range	Bought May & June	Placed in lot
	thousand dollars									index	head		
1	1,085	31	5	433	426	24	33	193	11	83	3,998	1,002	5,000
2	1,090	34	5	397	425	24	35	193	54	92	4,816	184	5,000
3	1,087	33	5	386	426	24	34	193	63	91	4,530	470	5,000
4	1,089	27	5	395	425	24	32	193	50	71	3,830	1,170	5,000
5	1,084	25	5	454	426	24	31	193	-14	92	3,020	1,980	5,000
6	1,084	29	5	454	427	24	32	193	-12	77	3,514	1,486	5,000
7	1,087	33	5	397	425	24	34	193	52	91	4,426	574	5,000
8	1,088	30	5	408	425	24	34	193	37	81	4,028	972	5,000
9	1,089	29	5	432	426	24	33	193	15	78	4,024	976	5,000
10	1,090	27	5	401	424	24	33	193	46	68	3,910	1,090	5,000
11	1,090	34	5	389	425	24	34	193	63	97	4,682	318	5,000
12	1,084	28	5	433	426	24	32	193	9	74	3,406	1,596	5,000
13	1,086	30	5	436	425	24	33	193	10	81	3,904	1,096	5,000
14	1,090	33	5	406	425	24	34	193	46	93	4,658	342	5,000
15	1,089	31	5	408	425	24	34	193	43	86	4,302	698	5,000
16	1,090	34	5	386	424	24	34	193	66	95	4,632	368	5,000
17	1,088	28	5	413	425	24	32	193	33	72	3,716	1,284	5,000
18	1,086	29	5	428	425	24	32	193	17	76	3,614	1,386	5,000
19	1,086	30	5	421	425	24	32	193	25	79	3,720	1,280	5,000
20	1,087	21	5	437	425	24	32	193	8	70	3,518	1,482	5,000
21	1,088	28	5	447	424	24	32	193	1	72	3,594	1,406	5,000
22	1,092	34	5	355	424	24	35	193	101	100	4,820	180	5,000
23	1,086	26	5	447	425	24	31	193	- 4	67	3,158	1,842	5,000
24	1,087	29	5	429	424	24	32	193	19	76	3,724	1,276	5,000
25	1,086	31	5	447	425	24	33	193	1	84	3,854	1,146	5,000
26	1,093	34	5	397	424	24	35	193	59	98	4,908	92	5,000
27	1,093	34	5	359	423	24	35	193	97	97	4,804	196	5,000
28	1,084	28	5	441	425	24	31	193	1	72	3,100	1,900	5,000
29	1,087	25	5	461	424	24	31	193	-16	54	3,010	1,990	5,000
30	1,092	28	5	414	424	24	33	193	36	73	3,904	1,096	5,000
31	1,089	30	5	394	424	24	33	193	57	80	3,944	1,056	5,000
32	1,086	27	5	440	424	24	31	193	5	71	3,226	1,774	5,000
33	1,087	28	5	442	424	24	32	193	4	73	3,420	1,580	5,000
34	1,089	33	5	441	424	24	34	193	13	93	3,286	714	5,000
35	1,093	34	5	381	423	24	35	193	76	96	4,760	240	5,000
36	1,092	28	5	431	423	24	33	193	21	76	3,956	1,044	5,000
37	1,094	33	5	392	423	24	35	193	65	99	4,890	110	5,000
38	1,094	33	5	361	423	24	35	193	97	97	4,764	236	5,000
39	1,087	33	5	422	423	24	33	193	30	90	3,960	1,140	5,000
40	1,088	26	5	479	424	24	31	193	-32	65	3,012	1,988	5,000

TABLE C-8

Summary of Simulation Results: 1956 Prices, Model C

	Total revenue			Variable costs							Total number of cattle		
	Sales			Total cost of	Total feed	Direct exp. in	Int. on	Total fixed	Net	Av. range	Placed on	Bought May &	Placed in
Year	Cattle	Barley	Manure	cattle	cost	lot	oper. cap.	costs	income	cond.	range	June	lot
	thousand dollars									index	head		
1	930	31	4	395	364	20	30	193	-38	83	3,998	275	4,273
2	1,060	34	5	382	419	23	34	193	56	92	4,817	48	4,865
3	1,014	33	5	348	402	22	33	193	58	91	4,531	123	4,654
4	904	27	4	302	357	20	29	193	40	71	3,831	307	4,138
5	772	25	4	296	305	17	25	193	-31	92	3,020	520	3,540
6	849	29	4	337	336	18	27	193	-26	77	3,485	420	3,905
7	997	33	5	351	395	22	32	193	52	91	4,426	151	4,577
8	935	30	4	331	369	21	31	193	29	81	4,029	255	4,284
9	934	29	4	354	369	21	30	193	7	78	4,024	256	4,280
10	919	27	4	314	360	20	29	193	37	68	3,910	286	4,196
11	1,040	34	5	364	410	23	33	193	60	97	4,683	83	4,766
12	832	28	4	306	329	18	27	193	- 8	74	3,406	419	3,825
13	913	30	4	348	361	20	29	193	0	81	3,903	288	4,191
14	1,036	33	5	379	403	23	33	193	43	93	4,657	90	4,747
15	979	31	4	353	380	22	31	193	36	86	4,669	183	4,486
16	1,032	34	5	357	402	23	33	193	63	95	4,631	97	4,728
17	886	28	4	311	344	19	28	193	22	72	3,716	337	4,053
18	866	29	4	317	337	19	28	193	5	76	3,613	364	3,977
19	885	30	4	319	344	19	28	193	14	79	3,721	336	4,057
20	853	27	4	320	331	19	27	193	- 6	70	3,516	390	3,906
21	866	28	4	335	335	19	28	193	-12	72	3,594	369	3,963
22	1,063	34	5	340	412	23	34	193	99	100	4,820	47	4,867
23	795	26	4	300	308	17	25	193	-19	67	3,157	484	3,642
24	886	29	4	327	344	19	28	193	7	76	3,724	335	4,060
25	906	31	4	356	351	20	29	193	- 8	84	3,854	301	4,155
26	1,079	34	5	343	418	24	35	193	58	98	4,908	24	4,932
27	1,061	34	5	343	411	23	34	193	96	97	4,803	52	4,855
28	784	28	4	280	305	17	25	193	- 4	72	3,100	499	3,599
29	774	25	4	312	297	17	25	193	-44	54	3,010	523	3,533
30	918	28	4	328	354	20	29	193	27	73	3,904	288	4,192
31	923	30	4	310	357	20	30	193	43	80	3,942	278	4,220
32	798	27	4	299	311	18	26	193	-10	71	3,226	466	3,692
33	837	28	4	316	324	18	27	193	-10	73	3,419	415	3,834
34	977	34	5	384	378	21	31	193	7	93	4,286	188	4,474
35	1,055	34	5	362	408	23	34	193	74	96	4,760	63	4,823
36	927	29	4	347	357	20	30	193	13	76	3,955	274	4,230
37	1,077	33	5	384	416	24	34	193	64	99	4,890	29	4,919
38	1,056	33	5	342	408	23	34	193	94	97	4,764	62	4,826
39	908	33	4	331	351	20	28	193	20	90	3,859	300	4,159
40	774	26	4	321	297	17	25	193	-49	65	3,011	522	3,533

TABLE C-9

Summary of Simulation Results: 1957 Prices, Model A

Year	Total revenue: Sales: Cattle	Barley	Manure	Variable costs: Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Bought May & June	Placed in lot
	thousand dollars									index	head		
1	1,120	28	5	492	377	24	35	193	32	83	3,998	906	4,904
2	1,145	31	5	454	384	24	37	193	89	97	4,817	165	4,982
3	1,136	30	5	435	381	24	36	193	101	91	4,530	424	4,954
4	1,121	25	5	436	377	23	34	193	87	71	3,831	1,055	4,886
5	1,095	23	5	502	368	23	32	193	3	57	3,020	1,787	4,807
6	1,104	27	5	514	372	23	34	193	- 1	77	3,515	1,340	4,855
7	1,132	30	5	451	380	24	36	193	83	91	4,427	517	4,944
8	1,123	28	5	460	377	24	36	193	67	81	4,028	877	4,905
9	1,125	27	5	490	378	24	35	193	37	78	4,022	882	4,905
10	1,125	24	5	452	376	23	35	193	74	68	3,910	984	4,894
11	1,142	31	5	436	382	24	37	193	106	97	4,682	287	4,969
12	1,101	26	5	483	371	23	34	193	29	74	3,407	1,438	4,845
13	1,118	28	5	491	375	23	35	193	32	81	3,903	990	4,893
14	1,142	31	5	463	382	24	37	193	80	93	4,658	309	4,967
15	1,132	29	5	464	379	24	36	193	70	86	4,303	629	4,932
16	1,141	31	5	435	381	24	37	193	107	95	4,632	332	4,964
17	1,117	25	5	459	374	23	34	193	63	72	3,716	1,159	4,875
18	1,110	26	5	476	373	23	34	193	44	76	3,613	1,252	4,865
19	1,114	27	5	467	374	23	34	193	54	79	3,720	1,155	4,875
20	1,111	25	5	489	372	23	34	193	29	70	3,517	1,338	4,855
21	1,112	25	5	506	372	23	34	193	13	72	3,593	1,270	4,863
22	1,148	31	5	416	383	24	36	193	153	100	4,819	163	4,982
23	1,099	24	5	494	368	23	33	193	16	67	3,157	1,663	4,820
24	1,117	26	5	479	374	23	34	193	46	76	3,725	1,151	4,875
25	1,117	28	5	507	373	23	36	193	18	84	3,854	1,034	4,889
26	1,151	31	5	455	383	24	37	193	93	98	4,908	83	4,991
27	1,148	31	5	401	382	24	37	193	148	97	4,804	177	4,931
28	1,093	25	5	473	366	23	33	193	35	72	3,100	1,715	4,815
29	1,098	23	5	526	367	23	32	193	-17	54	3,010	1,796	4,806
30	1,125	26	5	467	375	23	35	193	62	73	3,904	989	4,893
31	1,123	27	5	436	375	24	35	193	93	80	3,943	954	4,897
32	1,100	25	5	484	367	23	33	193	26	71	3,227	1,600	4,827
33	1,106	26	5	493	369	23	33	193	24	73	3,419	1,427	4,846
34	1,131	31	5	503	377	24	36	193	34	93	4,286	644	4,930
35	1,148	31	5	435	381	24	37	193	114	96	4,760	217	4,977
36	1,126	26	5	488	375	24	35	193	43	76	3,955	943	4,898
37	1,152	31	5	449	382	24	37	193	103	99	4,890	99	4,989
38	1,148	31	5	400	381	24	37	193	148	97	4,764	213	4,977
39	1,116	30	5	464	372	23	35	193	64	90	3,860	1,029	4,889
40	1,098	24	5	537	366	23	32	193	-26	65	3,011	1,795	4,806

TABLE C-10

Summary of Simulation Results: 1957 Prices, Models B, C

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on oper. cap.	Total fixed costs	Net income	Av. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,141	28	5	503	384	24	35	193	35	83	4,014	986	5,000
2	1,149	31	5	457	386	24	37	193	89	92	4,816	184	5,000
3	1,146	30	5	441	384	24	37	193	102	91	4,530	470	5,000
4	1,146	25	5	450	386	24	35	193	89	71	3,830	1,170	5,000
5	1,138	23	5	526	383	24	34	193	5	92	3,020	1,980	5,000
6	1,135	27	5	531	383	24	34	193	1	77	3,514	1,486	5,000
7	1,145	30	5	458	384	24	36	193	84	91	4,426	574	5,000
8	1,143	28	5	471	384	24	37	193	66	81	4,028	972	5,000
9	1,146	27	5	503	384	24	35	193	39	78	4,024	976	5,000
10	1,148	24	5	464	384	24	35	193	76	68	3,910	1,090	5,000
11	1,149	31	5	450	384	24	37	193	107	97	4,682	318	5,000
12	1,136	36	5	502	382	24	34	193	31	74	3,406	1,594	5,000
13	1,130	38	5	504	383	24	35	193	33	81	3,904	1,096	5,000
14	1,149	31	5	467	384	24	37	193	80	93	4,658	342	5,000
15	1,147	29	5	472	384	24	36	193	71	86	4,302	698	5,000
16	1,149	31	5	440	383	24	37	193	108	95	4,632	368	5,000
17	1,145	25	5	475	384	24	35	193	64	72	3,716	1,284	5,000
18	1,140	26	5	492	382	24	35	193	45	76	3,614	1,386	5,000
19	1,141	27	5	482	383	24	35	193	56	79	3,720	1,280	5,000
20	1,142	24	5	507	382	24	34	193	31	70	3,518	1,482	5,000
21	1,142	25	5	523	383	24	35	193	15	72	3,594	1,406	5,000
22	1,152	31	5	398	383	24	37	193	151	100	4,820	180	5,000
23	1,139	24	5	516	382	24	34	193	18	67	3,158	1,842	5,000
24	1,144	36	5	494	382	24	35	193	48	76	3,724	1,276	5,000
25	1,141	28	5	521	331	24	35	193	19	84	3,854	1,146	5,000
26	1,154	31	5	456	384	24	37	193	94	98	4,908	92	5,000
27	1,152	31	5	403	383	24	37	193	147	97	4,804	196	5,000
28	1,133	25	5	496	381	24	33	193	37	72	3,100	1,900	5,000
29	1,141	23	5	550	331	24	33	193	- 14	54	3,010	1,990	5,000
30	1,148	26	5	430	383	24	35	193	64	73	3,904	1,096	5,000
31	1,146	27	5	449	382	24	35	193	94	80	3,944	1,056	5,000
32	1,138	25	5	507	381	24	34	193	29	71	3,226	1,774	5,000
33	1,140	26	5	512	381	24	34	193	26	73	3,420	1,580	5,000
34	1,146	31	5	512	382	24	36	193	34	93	3,286	719	5,000
35	1,153	31	5	437	382	24	37	193	115	96	4,760	240	5,000
36	1,148	26	5	502	382	24	35	193	44	76	3,956	1,044	5,000
37	1,155	31	5	449	383	24	37	193	104	99	4,890	110	5,000
38	1,153	31	5	404	383	24	37	193	149	97	4,764	236	5,000
39	1,141	30	5	477	380	24	35	193	64	90	3,960	1,140	5,000
40	1,139	24	5	561	381	24	33	193	- 23	65	3,012	1,988	5,000

TABLE C-11

Summary of Simulation Results: 1958 Prices, Model A

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,036	28	4	514	319	17	38	193	12	83	3,998	0	3,998
2	1,243	31	5	586	382	23	46	193	47	97	4,817	0	4,817
3	1,168	30	5	520	360	22	44	193	65	91	4,530	0	4,530
4	991	25	4	418	302	18	38	193	49	71	3,831	0	3,831
5	782	22	3	382	237	14	32	193	-51	57	3,020	0	3,020
6	909	26	4	468	279	17	36	193	-54	77	3,515	0	3,515
7	1,143	30	4	523	351	21	43	193	46	91	4,427	0	4,427
8	1,041	27	4	476	319	19	42	193	23	81	4,029	0	4,029
9	1,040	27	4	514	318	19	40	193	-14	78	4,024	0	4,024
10	1,011	24	4	446	308	19	39	193	34	68	3,910	0	3,910
11	1,209	31	5	546	371	22	45	193	67	97	4,682	0	4,682
12	882	26	3	413	270	16	35	193	-17	74	3,406	0	3,406
13	1,009	27	4	499	309	19	39	193	-17	81	3,903	0	3,903
14	1,204	30	5	574	368	22	45	193	35	93	4,657	0	4,657
15	1,112	29	4	521	340	21	42	193	27	86	4,303	0	4,303
16	1,197	31	5	536	366	22	45	193	70	95	4,632	0	4,632
17	962	25	4	430	293	18	37	193	20	72	3,716	0	3,716
18	936	26	4	436	285	17	37	193	- 3	76	3,613	0	3,613
19	964	27	4	442	294	18	37	193	10	79	3,721	0	3,721
20	912	25	4	438	276	17	36	193	-21	70	3,517	0	3,517
21	931	25	4	434	284	17	36	193	- 4	72	3,593	0	3,593
22	1,246	31	5	550	380	23	46	193	89	100	4,820	0	4,820
23	820	24	3	393	248	15	33	193	-35	67	3,158	0	3,158
24	966	26	4	456	293	18	37	193	- 2	76	3,724	0	3,724
25	998	28	4	510	305	18	39	193	-35	84	3,854	0	3,854
26	1,269	31	5	602	388	24	47	193	51	98	4,908	0	4,908
27	1,243	31	5	517	379	23	46	193	119	97	4,803	0	4,803
28	805	25	3	357	245	15	32	193	- 8	72	3,100	0	3,100
29	783	22	3	411	234	14	32	193	-76	54	3,010	0	3,010
30	1,013	25	4	466	307	19	39	193	- 8	73	3,904	0	3,904
31	1,022	27	4	435	310	18	39	193	84	80	3,811	0	3,811
32	839	25	3	393	252	15	33	193	-21	71	3,227	0	3,227
33	888	25	3	429	270	16	35	193	-26	73	3,419	0	3,419
34	1,111	30	4	571	337	21	42	193	-19	93	4,286	0	4,286
35	1,232	31	5	551	376	23	46	193	79	96	4,760	0	4,760
36	1,026	26	4	502	310	19	39	193	- 7	76	3,955	0	3,955
37	1,266	31	5	589	385	23	47	193	64	99	4,890	0	4,890
38	1,234	31	5	513	376	23	46	193	119	97	4,764	0	4,764
39	1,002	30	4	463	304	19	39	193	18	90	3,859	0	3,859
40	784	23	3	423	235	14	32	193	-87	65	3,011	0	3,011

TABLE C-12

Summary of Simulation Results: 1958 Prices, Models B, C

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,289	28	5	610	400	24	45	193	- 7	83	3,998	1,002	5,000
2	1,289	31	5	615	397	24	47	193	49	97	4,816	184	5,000
3	1,289	30	5	594	397	24	46	193	69	91	4,530	470	5,000
4	1,290	25	5	603	398	24	44	193	58	71	3,830	1,170	5,000
5	1,290	22	5	695	400	24	42	193	-37	57	3,020	1,980	5,000
6	1,289	26	5	703	400	24	43	193	-43	77	3,514	1,486	5,000
7	1,290	30	5	614	398	24	46	193	49	91	4,426	574	5,000
8	1,290	29	5	629	398	24	47	193	31	81	4,028	972	5,000
9	1,290	27	5	668	397	24	45	193	- 6	78	4,024	976	5,000
10	1,290	24	5	618	397	24	46	193	42	68	3,910	1,090	5,000
11	1,291	31	5	596	397	24	47	193	68	97	4,682	318	5,000
12	1,290	26	5	666	400	24	43	193	- 4	74	3,406	1,594	5,000
13	1,291	27	5	672	398	24	45	193	-10	81	3,904	1,096	5,000
14	1,291	30	5	628	397	24	47	193	38	93	4,658	342	5,000
15	1,291	29	5	631	396	24	46	193	32	86	4,302	698	5,000
16	1,291	31	5	573	397	24	47	193	94	95	4,632	368	5,000
17	1,291	25	5	654	397	24	44	193	9	72	3,716	1,284	5,000
18	1,292	26	5	656	398	24	44	193	7	76	3,614	1,386	5,000
19	1,292	27	5	644	398	24	44	193	20	79	3,720	1,280	5,000
20	1,292	25	5	673	398	24	43	193	-10	70	3,518	1,482	5,000
21	1,292	25	5	692	397	24	44	193	-29	72	3,594	1,406	5,000
22	1,292	31	5	542	396	24	47	193	126	100	4,820	180	5,000
23	1,292	24	5	684	398	24	42	193	-22	67	3,158	1,842	5,000
24	1,292	26	5	658	397	24	44	193	8	76	3,724	1,276	5,000
25	1,292	28	5	692	398	24	44	193	-26	84	3,854	1,146	5,000
26	1,293	31	5	616	395	24	48	193	52	98	4,908	92	5,000
27	1,293	31	5	549	395	24	47	193	120	97	4,804	196	5,000
28	1,293	25	5	657	400	24	42	193	6	72	3,100	1,900	5,000
29	1,293	22	5	725	397	24	42	193	-61	54	3,010	1,990	5,000
30	1,293	25	5	640	396	24	45	193	20	73	3,904	1,096	5,000
31	1,293	27	5	602	397	24	45	193	65	80	3,944	1,056	5,000
32	1,293	25	5	673	397	24	43	193	- 8	71	3,226	1,774	5,000
33	1,293	25	5	679	398	24	43	193	-14	73	3,420	1,580	5,000
34	1,294	30	5	684	396	24	46	193	-14	93	3,286	714	5,000
35	1,294	31	5	589	395	24	47	193	80	96	4,760	240	5,000
36	1,293	26	5	667	396	24	45	193	1	76	3,956	1,044	5,000
37	1,294	31	5	607	394	24	48	193	64	99	4,890	110	5,000
38	1,295	31	5	543	395	24	47	193	120	97	4,764	236	5,000
39	1,293	30	5	649	397	24	44	193	27	90	3,960	1,140	5,000
40	1,295	23	5	739	397	24	42	193	-72	65	3,012	1,988	5,000

TABLE C-13

Summary of Simulation Results: 1959 Prices, Model A

Year	Total revenue			Variable costs				Total fixed costs	Net income	Avg. range cond.	Total number of cattle		
	Sales			Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.				Placed on range	Bought May & June	Placed in lot
	Cattle	Barley	Manure										
	thousand dollars									index	head		
1	1,195	29	5	608	363	22	45	193	- 7	83	3,998	618	4,616
2	1,303	32	5	626	394	24	49	193	54	97	4,817	93	4,910
3	1,264	31	5	614	383	23	47	193	40	91	4,530	239	4,769
4	1,177	26	4	503	355	21	43	193	91	71	3,830	596	4,426
5	1,069	23	4	551	323	19	38	193	-30	57	3,018	1,007	4,025
6	1,128	27	4	596	342	20	41	193	-35	77	3,515	756	4,271
7	1,251	31	5	589	379	23	47	193	57	91	4,427	292	4,719
8	1,200	28	5	570	362	22	46	193	5	81	4,028	495	4,523
9	1,201	27	5	608	363	22	44	193	6	78	4,024	497	4,521
10	1,188	25	4	545	358	21	44	193	87	68	3,910	555	4,465
11	1,286	32	5	606	389	23	48	193	64	97	4,682	162	4,844
12	1,115	26	4	535	337	20	41	193	18	74	3,406	811	4,217
13	1,182	28	4	621	358	21	44	193	-21	81	3,903	559	4,462
14	1,284	31	5	627	388	23	48	193	42	93	4,658	174	4,832
15	1,235	29	5	595	373	22	46	193	41	86	4,303	355	4,658
16	1,280	32	5	591	386	23	48	193	73	95	4,632	187	4,819
17	1,162	26	4	555	350	21	42	193	34	72	3,716	654	4,370
18	1,145	27	4	564	346	21	42	193	10	76	3,613	706	4,319
19	1,159	28	4	565	350	21	42	193	21	79	3,720	652	4,372
20	1,135	25	4	572	342	20	41	193	- 3	70	3,417	755	4,172
21	1,145	26	4	590	345	20	42	193	-16	72	3,556	716	4,272
22	1,306	32	5	562	392	24	49	193	122	100	4,819	92	4,911
23	1,087	25	4	554	328	20	39	193	-17	67	3,157	938	4,095
24	1,163	27	4	577	350	21	43	193	10	76	3,724	650	4,374
25	1,176	29	4	617	354	21	43	193	-19	84	3,854	583	4,437
26	1,319	32	5	635	396	24	50	193	58	98	4,907	48	4,955
27	1,305	32	5	566	393	24	50	193	117	97	4,802	101	4,903
28	1,076	26	4	524	323	19	38	193	8	72	3,099	968	4,067
29	1,071	23	4	576	321	19	38	193	-51	54	3,011	1,012	4,023
30	1,189	26	4	570	357	21	44	193	36	73	3,905	557	4,462
31	1,191	28	4	542	358	21	44	193	66	80	3,943	538	4,481
32	1,096	26	4	549	329	20	40	193	- 5	71	3,221	903	4,124
33	1,121	26	4	549	337	20	41	193	- 9	73	3,420	804	4,224
34	1,236	31	5	648	370	22	46	193	- 8	93	4,285	364	4,649
35	1,300	32	5	595	391	23	49	193	53	96	4,760	122	4,882
36	1,196	27	4	598	358	22	44	193	46	76	3,955	532	4,487
37	1,318	32	5	626	394	24	50	193	67	99	4,890	56	4,946
38	1,301	32	5	568	390	23	49	193	114	97	4,764	120	4,884
39	1,177	30	4	584	353	21	43	193	19	90	3,859	581	4,440
40	1,071	24	4	589	320	19	38	193	-62	65	3,010	1,013	4,023

TABLE C-14

Summary of Simulation Results: 1959 Prices, Models B, C

Year	Total revenue: Sales: Cattle	Barley	Manure	Variable costs: Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Bought May & June	Placed in lot
	thousand dollars									index	head		
1	1,320	29	5	689	402	24	47	193	1	83	3,998	1,002	5,000
2	1,326	32	5	642	402	24	50	193	53	97	4,816	184	5,000
3	1,323	31	5	621	401	24	49	193	70	91	4,530	470	5,000
4	1,325	26	5	631	402	24	46	193	60	71	3,830	1,170	5,000
5	1,319	23	5	714	402	24	43	193	-29	57	3,020	1,980	5,000
6	1,316	27	5	718	401	24	45	193	-33	77	3,514	1,486	5,000
7	1,323	31	5	637	401	24	48	193	56	91	4,426	574	5,000
8	1,322	28	5	650	401	24	49	193	39	81	4,028	972	5,000
9	1,325	27	5	687	401	24	47	193	5	78	4,024	976	5,000
10	1,326	25	5	636	402	24	46	193	56	68	3,910	1,090	5,000
11	1,326	32	5	632	401	24	49	193	64	97	4,682	318	5,000
12	1,317	26	5	684	400	24	45	193	2	74	3,406	1,594	5,000
13	1,320	28	5	694	401	24	46	193	- 4	81	3,904	1,096	5,000
14	1,327	31	5	655	401	24	49	193	42	93	4,658	342	5,000
15	1,325	29	5	653	401	24	48	193	41	86	4,302	698	5,000
16	1,327	32	5	624	401	24	49	193	73	95	4,632	368	5,000
17	1,324	26	5	657	401	24	46	193	34	72	3,716	1,284	5,000
18	1,320	27	5	680	400	24	45	193	10	76	3,614	1,386	5,000
19	1,321	28	5	669	401	24	46	193	21	79	3,720	1,280	5,000
20	1,322	25	5	694	400	24	45	193	- 3	70	3,518	1,482	5,000
21	1,323	26	5	706	400	24	45	193	-15	72	3,594	1,406	5,000
22	1,329	32	5	758	401	24	50	193	121	100	4,820	180	5,000
23	1,320	25	5	705	400	24	44	193	-16	67	3,158	1,842	5,000
24	1,323	27	5	682	400	24	46	193	10	76	3,724	1,276	5,000
25	1,321	29	5	711	400	24	46	193	-18	84	3,854	1,146	5,000
26	1,331	32	5	643	400	24	50	193	57	98	4,908	92	5,000
27	1,330	32	5	583	400	24	50	193	118	97	4,804	196	5,000
28	1,315	26	5	680	398	24	44	193	7	72	3,100	1,900	5,000
29	1,322	23	5	740	400	24	43	193	-50	54	3,010	1,990	5,000
30	1,328	26	5	660	400	24	46	193	36	73	3,904	1,096	5,000
31	1,325	28	5	629	398	24	47	193	66	80	3,944	1,056	5,000
32	1,320	26	5	694	400	24	44	193	- 4	71	3,226	1,774	5,000
33	1,320	26	5	700	398	24	45	193	- 8	73	3,420	1,580	5,000
34	1,326	31	5	706	398	24	48	193	- 9	93	4,286	714	5,000
35	1,330	32	5	615	400	24	49	193	87	96	4,760	240	5,000
36	1,328	27	5	684	398	24	47	193	14	76	3,956	1,044	5,000
37	1,332	32	5	635	400	24	50	193	67	99	4,890	110	5,000
38	1,330	32	5	588	398	24	49	193	115	97	4,764	236	5,000
39	1,322	30	5	677	398	24	46	193	13	90	3,960	1,140	5,000
40	1,322	24	5	753	398	24	43	193	-61	65	3,012	1,988	5,000

TABLE C-15

Summary of Simulation Results: 1960 Prices, Models A, B, C

Year	Total revenue: Sales: Cattle	Barley	Manure	Variable costs: Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Bought May & June	Placed in lot
	thousand dollars									index	head		
1	1,216	27	5	625	384	24	42	193	-21	83	3,998	1,002	5,000
2	1,225	30	5	582	382	24	45	193	36	97	4,816	184	5,000
3	1,222	29	5	561	383	24	44	193	51	91	4,530	470	5,000
4	1,223	24	5	567	383	24	42	193	43	71	3,830	1,170	5,000
5	1,212	22	5	645	384	24	40	193	-47	57	3,020	1,980	5,000
6	1,210	26	5	653	384	24	41	193	-55	77	3,514	1,486	5,000
7	1,220	29	5	577	382	24	44	193	34	91	4,426	574	5,000
8	1,219	27	5	588	383	24	44	193	17	81	4,028	972	5,000
9	1,222	26	5	625	383	24	43	193	-14	78	4,024	976	5,000
10	1,224	24	5	576	382	24	42	193	35	68	3,910	1,090	5,000
11	1,225	30	5	568	382	24	45	193	47	97	4,682	318	5,000
12	1,210	25	5	619	384	24	41	193	-20	74	3,406	1,594	5,000
13	1,216	27	5	629	386	24	42	193	-24	81	3,904	1,096	5,000
14	1,226	30	5	593	382	24	44	193	24	93	4,658	342	5,000
15	1,222	28	5	592	382	24	43	193	21	86	4,302	698	5,000
16	1,225	30	5	563	382	24	44	193	53	95	4,632	368	5,000
17	1,221	25	5	593	382	24	42	193	15	72	3,716	1,284	5,000
18	1,215	26	5	613	383	24	41	193	- 9	76	3,614	1,386	5,000
19	1,173	26	5	604	382	24	42	193	2	79	3,720	1,280	5,000
20	1,261	24	5	627	383	24	41	193	-23	70	3,518	1,482	5,000
21	1,217	25	5	643	382	24	41	193	-36	72	3,594	1,406	5,000
22	1,228	30	5	517	381	24	45	193	102	100	4,820	180	5,000
23	1,214	23	5	637	383	24	40	193	-34	67	3,158	1,842	5,000
24	1,220	26	5	617	382	24	42	193	- 8	76	3,724	1,276	5,000
25	1,216	27	5	645	382	24	42	193	-39	84	3,854	1,146	5,000
26	1,230	30	5	583	381	24	45	193	39	98	4,908	92	5,000
27	1,228	30	5	521	381	24	45	193	97	97	4,804	196	5,000
28	1,207	25	5	614	383	24	40	193	-16	72	3,100	1,900	5,000
29	1,216	22	5	672	383	24	40	193	-67	54	3,010	1,990	5,000
30	1,225	25	5	597	381	24	42	193	16	73	3,904	1,096	5,000
31	1,221	27	5	566	381	24	42	193	45	80	3,944	1,056	5,000
32	1,213	24	5	628	382	24	40	193	-26	71	3,226	1,774	5,000
33	1,215	25	5	632	382	24	41	193	-29	73	3,420	1,580	5,000
34	1,221	30	5	642	381	24	43	193	-26	93	3,286	714	5,000
35	1,229	30	5	557	381	24	45	193	65	96	4,760	240	5,000
36	1,225	26	5	621	381	24	42	193	- 7	76	3,956	1,044	5,000
37	1,231	30	5	575	380	24	45	193	49	99	4,890	110	5,000
38	1,230	30	5	526	381	24	45	193	36	97	4,764	236	5,000
39	1,215	29	5	608	381	24	42	193	60	90	3,960	1,140	5,000
40	1,215	23	5	683	381	24	40	193	-79	65	3,012	1,988	5,000

TABLE C-16

Summary of Simulation Results: 1961 Prices, Models A, B, C

Year	Total revenue			Variable costs				Total fixed costs	Net income	Avg. range cond.	Total number of cattle		
	Sales			Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.				Placed on range	Bought May & June	Placed in lot
	Cattle	Barley	Manure										
	thousand dollars									index	head		
1	1,194	29	5	609	413	24	40	193	- 51	83	3,998	1,002	5,000
2	1,195	32	5	573	411	24	42	193	- 13	97	4,816	184	5,000
3	1,194	31	5	551	412	24	41	193	9	91	4,530	470	5,000
4	1,194	26	5	548	412	24	39	193	8	71	3,830	1,170	5,000
5	1,194	23	5	617	413	24	37	193	-134	57	3,020	1,980	5,000
6	1,195	27	5	630	413	24	38	193	- 1	77	3,514	1,486	5,000
7	1,195	31	5	566	412	24	41	193	- 4	91	4,426	574	5,000
8	1,195	28	5	572	412	24	42	193	- 15	81	4,028	972	5,000
9	1,195	28	5	608	411	24	40	193	- 49	78	4,024	976	5,000
10	1,196	25	5	509	411	24	40	193	- 2	68	3,910	1,090	5,000
11	1,196	32	5	609	411	24	42	193	4	97	4,682	318	5,000
12	1,195	27	5	596	413	24	38	193	- 37	74	3,406	1,594	5,000
13	1,195	28	5	610	412	24	40	193	- 51	81	3,904	1,096	5,000
14	1,196	32	5	583	411	24	42	193	- 21	93	4,658	342	5,000
15	1,197	28	5	579	411	24	41	193	- 19	86	4,302	698	5,000
16	1,197	32	5	554	411	24	42	193	10	95	4,632	368	5,000
17	1,196	26	5	572	411	24	39	193	- 14	72	3,716	1,284	5,000
18	1,195	27	5	592	412	24	39	193	- 32	76	3,614	1,386	5,000
19	1,196	28	5	584	412	24	39	193	- 23	79	3,720	1,280	5,000
20	1,197	26	5	605	411	24	38	193	- 46	70	3,518	1,482	5,000
21	1,196	26	5	620	412	24	39	193	- 61	72	3,594	1,406	5,000
22	1,197	32	5	511	410	24	42	193	54	100	4,820	180	5,000
23	1,197	25	5	610	411	24	37	193	- 50	67	3,158	1,842	5,000
24	1,196	27	5	596	411	24	39	193	- 25	76	3,724	1,276	5,000
25	1,197	29	5	626	412	24	39	193	- 64	84	3,854	1,146	5,000
26	1,198	32	5	577	409	24	42	193	- 11	98	4,908	92	5,000
27	1,198	32	5	516	410	24	42	193	50	97	4,804	196	5,000
28	1,197	26	5	584	412	24	37	193	- 24	72	3,100	1,900	5,000
29	1,197	23	5	623	412	24	37	193	- 83	54	3,010	1,990	5,000
30	1,198	26	5	580	410	24	40	193	- 18	73	3,904	1,096	5,000
31	1,198	28	5	549	410	24	40	193	15	80	3,944	1,056	5,000
32	1,197	26	5	601	411	24	38	193	- 61	71	3,226	1,774	5,000
33	1,198	26	5	609	411	24	38	193	- 26	73	3,420	1,580	5,000
34	1,198	32	5	627	411	24	41	193	- 61	93	3,286	714	5,000
35	1,199	32	5	550	409	24	42	193	- 10	96	4,760	240	5,000
36	1,199	27	5	604	410	24	40	193	- 54	76	3,956	1,044	5,000
37	1,199	32	5	568	409	24	42	193	40	99	4,890	110	5,000
38	1,199	32	5	518	409	24	42	193	49	97	4,764	236	5,000
39	1,198	31	5	588	410	24	39	193	- 21	90	3,960	1,140	5,000
40	1,199	24	5	655	411	24	37	193	- 92	65	3,012	1,988	5,000

TABLE C-17

Summary of Simulation Results: 1962 Prices, Model A

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,194	30	5	572	387	22	41	193	15	83	3,998	595	4,593
2	1,281	34	5	575	416	24	45	193	66	97	4,817	107	4,924
3	1,250	33	5	537	405	23	44	193	85	91	4,531	275	4,806
4	1,175	27	5	498	380	22	40	193	73	71	3,831	687	4,518
5	1,088	24	4	528	351	20	36	193	-12	57	3,021	1,163	4,184
6	1,142	29	4	568	369	21	39	193	-15	77	3,515	873	4,388
7	1,239	33	5	547	401	23	44	193	69	91	4,428	336	4,764
8	1,197	30	5	534	387	22	43	193	52	81	4,029	570	4,599
9	1,197	29	5	571	387	22	41	193	15	78	4,023	574	4,597
10	1,184	26	5	515	382	22	41	193	62	68	3,909	641	4,550
11	1,267	34	5	552	410	23	45	193	83	97	4,683	186	4,869
12	1,131	28	4	526	364	21	38	193	21	74	3,407	936	4,343
13	1,185	30	5	539	382	22	43	193	40	81	3,904	644	4,548
14	1,265	33	5	605	408	23	45	193	29	93	4,658	201	4,859
15	1,227	31	5	555	396	23	43	193	53	86	4,302	410	4,712
16	1,263	34	5	544	407	23	45	193	88	95	4,632	216	4,848
17	1,164	27	4	518	376	21	40	193	48	72	3,715	755	4,470
18	1,154	28	4	532	372	21	39	193	29	76	3,612	816	4,428
19	1,166	29	4	529	375	21	40	193	41	79	3,720	752	4,472
20	1,143	27	4	541	368	21	39	193	13	70	3,516	872	4,388
21	1,152	27	4	602	371	21	39	193	- 2	72	3,593	827	4,420
22	1,284	34	5	470	503	24	46	193	14	100	4,820	106	4,926
23	1,109	26	4	527	354	20	37	193	3	67	3,157	1,083	4,240
24	1,163	28	4	542	376	21	40	193	28	76	3,725	749	4,474
25	1,181	31	5	581	379	22	41	193	0	84	3,854	674	4,528
26	1,294	34	5	583	416	24	46	193	70	98	4,618	344	4,962
27	1,282	34	5	515	412	24	45	193	132	97	4,803	116	4,919
28	1,101	27	4	498	353	20	37	193	31	72	3,101	1,116	4,217
29	1,091	24	4	554	350	20	36	193	-34	54	3,009	1,170	4,179
30	1,186	28	5	536	380	22	41	193	46	73	3,904	644	4,548
31	1,191	30	5	504	382	22	41	193	83	80	3,943	621	4,564
32	1,114	27	4	522	357	20	38	193	16	71	3,227	1,042	4,269
33	1,136	28	4	540	364	21	38	193	11	73	3,419	929	4,348
34	1,228	33	5	604	394	23	43	193	10	93	4,286	420	4,706
35	1,279	34	5	548	410	24	45	193	97	96	4,760	141	4,901
36	1,193	28	5	563	401	22	41	193	24	76	3,955	614	4,569
37	1,293	34	5	574	415	24	46	193	80	99	4,891	64	4,955
38	1,280	34	5	515	410	24	45	193	132	97	4,765	138	4,903
39	1,184	32	5	539	379	22	41	193	47	90	3,859	671	4,530
40	1,092	25	4	566	349	20	36	193	-43	65	3,011	1,169	4,180

TABLE C-18

Summary of Simulation Results: 1962 Prices, Models B, C

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on. oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,300	30	5	631	422	24	44	193	33	83	3,998	1,002	5,000
2	1,300	34	5	587	421	24	46	193	68	97	4,816	184	5,000
3	1,301	33	5	565	421	24	45	193	88	91	4,530	470	5,000
4	1,300	27	5	569	422	24	43	193	83	71	3,830	1,170	5,000
5	1,301	24	5	647	421	24	41	193	4	57	3,020	1,980	5,000
6	1,301	29	5	657	422	24	42	193	- 3	77	3,514	1,486	5,000
7	1,301	33	5	582	421	24	45	193	74	91	4,426	574	5,000
8	1,302	30	5	593	421	24	45	193	59	81	4,028	972	5,000
9	1,301	29	5	629	421	24	44	193	24	78	4,024	976	5,000
10	1,301	26	5	582	420	24	43	193	70	68	3,910	1,090	5,000
11	1,302	34	5	571	421	24	45	193	86	97	4,682	318	5,000
12	1,302	28	5	622	421	24	42	193	33	74	3,406	1,594	5,000
13	1,302	30	5	632	421	24	43	193	23	81	3,904	1,096	5,000
14	1,302	33	5	598	420	24	45	193	59	93	4,658	342	5,000
15	1,302	31	5	597	421	24	44	193	59	86	4,302	698	5,000
16	1,302	34	5	567	420	24	45	193	92	95	4,632	368	5,000
17	1,302	27	5	595	421	24	43	193	59	72	3,716	1,284	5,000
18	1,303	28	5	616	420	24	42	193	41	76	3,614	1,386	5,000
19	1,303	29	5	606	421	24	43	193	51	79	3,720	1,280	5,000
20	1,303	27	5	630	420	24	42	193	25	70	3,518	1,482	5,000
21	1,303	27	5	647	420	24	43	193	8	72	3,594	1,406	5,000
22	1,303	34	5	521	420	24	46	193	138	100	4,820	180	5,000
23	1,303	26	5	638	420	24	41	193	18	67	3,158	1,842	5,000
24	1,304	28	5	619	420	24	43	193	39	76	3,724	1,276	5,000
25	1,304	31	5	650	420	24	43	193	9	84	3,854	1,146	5,000
26	1,303	34	5	589	420	24	46	193	70	98	4,908	92	5,000
27	1,304	34	5	526	419	24	46	193	133	97	4,804	196	5,000
28	1,304	27	5	613	420	24	41	193	46	72	3,100	1,900	5,000
29	1,304	24	5	674	420	24	41	193	-17	54	3,010	1,990	5,000
30	1,304	28	5	602	419	24	43	193	55	73	3,904	1,096	5,000
31	1,305	30	5	568	420	24	43	193	90	80	3,944	1,056	5,000
32	1,305	27	5	629	419	24	41	193	30	71	3,226	1,774	5,000
33	1,305	28	5	635	420	24	42	193	24	73	3,420	1,580	5,000
34	1,304	33	5	647	419	24	44	193	16	93	3,286	714	5,000
35	1,305	34	5	562	419	24	46	193	100	96	4,760	240	5,000
36	1,305	28	5	627	419	24	43	193	32	76	3,956	1,044	5,000
37	1,305	34	5	580	419	24	46	193	81	99	4,820	110	5,000
38	1,306	34	5	529	419	24	46	193	134	97	4,764	236	5,000
39	1,306	32	5	608	419	24	43	193	56	90	3,960	1,140	5,000
40	1,304	25	5	686	419	24	41	193	-27	65	3,012	1,988	5,000

TABLE C-19

Summary of Simulation Results: 1963 Prices, Model A

Year	Total revenue: Sales: Cattle	Total revenue: Sales: Barley	Total revenue: Sales: Manure	Variable costs: Total cost of cattle	Variable costs: Total feed cost	Variable costs: Direct exp. in lot	Variable costs: Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Total number of cattle: Bought May & June	Total number of cattle: Placed in lot
	thousand dollars									index	head		
1	1,196	31	5	610	433	24	41	193	- 70	83	3,998	1,002	5,000
2	1,207	34	5	569	432	24	43	193	- 11	97	4,816	184	5,000
3	1,202	33	5	550	432	24	42	193	- 5	91	4,530	470	5,000
4	1,204	27	5	555	432	24	40	193	- 7	71	3,830	1,170	5,000
5	1,191	25	5	650	433	24	38	193	-116	57	3,020	1,980	5,000
6	1,188	29	5	612	433	24	39	193	- 79	77	3,514	1,486	5,000
7	1,202	33	5	564	432	24	42	193	- 16	91	4,426	574	5,000
8	1,199	30	5	575	432	24	43	193	- 62	81	4,028	972	5,000
9	1,203	29	5	609	433	24	41	193	- 31	78	4,024	976	5,000
10	1,206	27	5	562	431	24	40	193	- 14	68	3,910	1,090	5,000
11	1,206	34	5	558	432	24	43	193	- 4	97	4,682	318	5,000
12	1,189	28	5	603	432	24	39	193	- 70	74	3,406	1,594	5,000
13	1,195	30	5	613	432	24	40	193	- 72	81	3,904	1,096	5,000
14	1,207	33	5	580	432	24	43	193	- 25	93	4,658	342	5,000
15	1,203	31	5	579	433	24	42	193	- 29	86	4,302	698	5,000
16	1,206	34	5	552	431	24	43	193	3	95	4,632	368	5,000
17	1,201	28	5	578	431	24	40	193	- 33	72	3,716	1,284	5,000
18	1,194	29	5	649	432	24	40	193	- 59	76	3,614	1,386	5,000
19	1,196	30	5	589	432	24	40	193	- 48	79	3,720	1,280	5,000
20	1,197	27	5	611	431	24	39	193	- 69	70	3,518	1,482	
21	1,197	28	5	625	432	24	40	193	- 83	72	3,594	1,406	5,000
22	1,210	34	5	509	430	24	43	193	49	100	4,820	180	5,000
23	1,193	26	5	620	432	24	38	193	- 83	67	3,158	1,842	5,000
24	1,199	29	5	601	431	24	40	193	- 56	76	3,724	1,276	5,000
25	1,195	31	5	629	431	24	40	193	- 86	84	3,854	1,146	5,000
26	1,203	34	5	571	430	24	43	193	- 10	98	4,908	92	5,000
27	1,210	34	5	532	430	24	43	193	9	97	4,804	196	5,000
28	1,185	28	5	587	432	24	38	193	- 30	72	3,100	1,900	5,000
29	1,195	25	5	646	431	24	38	193	-113	54	3,010	1,990	5,000
30	1,206	28	5	572	430	24	41	193	- 32	73	3,904	1,096	5,000
31	1,201	30	5	575	431	24	41	193	- 6	80	3,944	1,056	5,000
32	1,192	27	5	632	431	24	39	193	- 74	71	3,226	1,774	5,000
33	1,193	28	5	594	431	24	39	193	- 77	73	3,420	1,580	5,000
34	1,201	33	5	826	430	24	42	193	- 74	93	3,286	714	5,000
35	1,211	34	5	346	430	24	43	193	14	96	4,760	240	5,000
36	1,214	24	5	649	429	24	41	193	- 53	76	3,956	1,044	5,000
37	1,214	34	5	520	430	24	43	193	- 1	99	4,890	110	5,000
38	1,211	34	5	518	429	24	43	193	43	97	4,764	236	5,000
39	1,194	33	5	589	431	24	40	193	44	90	3,960	1,140	5,000
40	1,193	26	5	617	430	24	38	193	79	65	3,012	1,988	5,000

TABLE C-20

Summary of Simulation Results: 1963 Prices, Model B

Year	Total revenue			Variable costs				Total fixed costs	Net income	Avg. range cond.	Total number of cattle		
	Sales			Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.				Placed on range	Bought May & June	Placed in lot
	Cattle	Barley	Manure										
	thousand dollars									index	head		
1	1,158	31	5	586	418	23	41	193	- 67	83	3,998	836	4,834
2	1,200	34	5	565	430	24	43	193	- 15	97	4,817	152	4,969
3	1,184	33	5	538	424	24	42	193	0	91	4,531	390	4,921
4	1,159	27	5	526	414	23	39	193	- 4	71	3,831	972	4,803
5	1,116	25	5	579	404	22	36	193	- 89	57	3,020	1,647	4,667
6	1,131	29	5	599	410	23	38	193	- 99	77	3,515	1,235	4,750
7	1,179	33	5	550	423	24	41	193	- 15	91	4,426	477	4,903
8	1,162	30	5	551	418	23	42	193	- 29	81	4,028	808	4,836
9	1,165	29	5	585	417	23	40	193	- 59	78	4,024	812	4,836
10	1,164	27	5	536	416	23	40	193	- 11	68	3,910	907	4,817
11	1,194	34	5	551	425	24	42	193	- 3	97	4,682	265	4,947
12	1,127	28	5	564	409	23	38	193	- 67	74	3,406	1,326	4,732
13	1,153	30	5	586	416	23	40	193	- 70	81	3,904	912	4,816
14	1,194	33	5	572	425	24	42	193	- 24	93	4,655	286	4,942
15	1,177	31	5	561	421	23	41	193	- 27	86	4,313	580	4,883
16	1,192	34	5	543	425	24	42	193	3	95	4,632	306	4,938
17	1,151	28	5	548	412	23	39	193	- 31	72	3,716	1,068	4,784
18	1,141	29	5	564	410	23	39	193	- 56	76	3,613	1,154	4,767
19	1,146	30	5	558	413	23	39	193	- 45	79	3,720	1,065	4,785
20	1,141	27	5	575	409	23	38	193	- 66	70	3,518	1,233	4,751
21	1,143	28	5	591	409	23	38	193	- 80	72	3,592	1,171	4,763
22	1,203	34	5	505	427	24	43	193	49	100	4,820	150	4,970
23	1,122	26	5	575	404	23	37	193	- 79	67	3,157	1,533	4,690
24	1,150	29	5	570	412	23	39	193	- 53	76	3,724	1,061	4,785
25	1,151	31	5	601	413	23	39	193	- 84	84	3,854	953	4,807
26	1,208	34	5	569	429	24	43	193	- 10	98	4,909	76	4,985
27	1,203	34	5	510	426	24	43	193	45	97	4,803	164	4,967
28	1,112	28	5	549	404	22	37	193	- 62	72	3,100	1,581	4,681
29	1,118	25	5	604	401	22	36	193	-108	54	3,010	1,655	4,665
30	1,164	28	5	556	413	23	40	193	- 29	73	3,904	912	4,816
31	1,161	30	5	528	415	23	40	193	- 3	80	3,943	879	4,822
32	1,123	27	5	568	405	23	37	193	- 70	71	3,227	1,475	4,702
33	1,133	28	5	577	407	23	38	193	- 73	73	3,420	1,314	4,734
34	1,173	33	5	609	419	23	41	193	- 73	93	4,287	593	4,880
35	1,202	34	5	540	426	24	43	193	15	96	4,761	199	4,960
36	1,165	29	5	580	413	23	40	193	- 51	76	3,955	869	4,824
37	1,209	34	5	561	426	24	43	193	- 1	99	4,891	91	4,982
38	1,202	34	5	513	425	24	43	193	44	97	4,764	196	4,960
39	1,150	33	5	566	413	23	40	193	- 48	90	3,859	949	4,808
40	1,117	26	5	615	401	22	36	193	-110	65	3,012	1,654	4,666

TABLE C-21

Summary of Simulation Results: 1963 Prices, Model C

Year	Total revenue: Sales: Cattle	Barley	Manure	Variable costs: Total cost of cattle	Total feed cost	Direct exp. in lot	Int. on oper. cap.	Total fixed costs	Net income	Avg. range cond.	Total number of cattle: Placed on range	Bought May & June	Placed in lot
	thousand dollars									index	head		
1	971	31	5	468	347	19	38	193	- 59	83	3,998	0	3,998
2	1,165	34	5	543	415	23	42	193	- 50	97	4,817	0	4,817
3	1,096	33	5	483	391	22	40	193	41	91	4,530	0	4,530
4	938	27	4	386	330	18	35	193	7	71	3,831	0	3,831
5	741	25	3	343	260	14	29	193	- 70	57	3,020	0	3,020
6	850	29	4	422	303	17	32	193	- 85	77	3,515	0	3,515
7	1,070	33	4	481	381	21	39	193	- 9	91	4,427	0	4,427
8	978	30	4	436	247	19	38	193	- 20	81	4,029	0	4,029
9	981	29	4	468	346	19	36	193	- 50	78	4,024	0	4,024
10	957	27	4	406	336	19	35	193	1	68	3,910	0	3,910
11	1,134	34	5	372	403	22	41	193	0	97	4,682	0	4,682
12	825	28	3	455	293	16	32	193	- 51	74	3,406	0	3,406
13	946	30	4	522	336	19	35	193	- 59	81	3,903	0	3,903
14	1,129	33	5	479	401	22	41	193	- 22	93	4,657	0	4,657
15	1,045	31	4	479	371	21	39	193	- 20	86	4,303	0	4,303
16	1,122	34	5	499	398	22	41	193	7	95	4,632	0	4,632
17	908	28	4	394	318	18	34	193	- 18	72	3,716	0	3,716
18	879	29	4	399	310	17	33	193	- 42	76	3,613	0	3,613
19	904	30	4	406	320	18	34	193	- 33	79	3,721	0	3,721
20	859	27	4	398	308	17	32	193	- 52	70	3,517	0	3,517
21	877	28	4	422	308	17	33	193	- 66	72	3,593	0	3,593
22	1,169	34	5	384	315	23	42	193	51	100	4,820	0	4,820
23	773	26	3	355	270	15	30	193	- 61	67	3,158	0	3,158
24	909	29	4	418	319	18	34	193	- 40	76	3,724	0	3,724
25	934	31	4	464	331	18	35	193	- 73	84	3,854	0	3,854
26	191	34	5	558	422	24	43	193	- 9	98	4,908	0	4,908
27	1,166	34	5	486	412	23	42	193	49	97	4,803	0	4,803
28	752	28	3	324	265	15	29	193	- 43	72	3,100	0	3,100
29	742	25	3	366	257	14	29	193	89	54	3,010	0	3,010
30	966	28	4	425	334	19	35	193	- 18	73	3,904	0	3,904
31	961	30	4	402	337	19	36	193	7	80	3,942	0	3,943
32	788	27	3	356	276	15	30	193	- 52	71	3,227	0	3,227
33	833	28	3	389	292	16	32	193	- 58	73	3,419	0	3,419
34	1,039	33	4	524	367	21	38	193	- 66	93	4,286	0	4,286
35	1,156	34	5	511	408	23	42	193	17	96	4,760	0	4,760
36	967	29	4	455	337	19	36	193	- 41	76	3,955	0	3,955
37	1,189	34	5	549	419	23	43	193	0	99	4,890	0	4,890
38	1,157	34	5	496	408	23	42	193	46	97	4,764	0	4,764
39	934	33	4	430	331	19	35	193	- 37	90	3,859	0	3,859
40	741	26	3	378	256	14	29	193	-100	65	3,011	0	3,011